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DISSERTATION

A HOLISTIC APPROACH TO VETERINARY PUBLIC HEALTH IN ANIMAL SHELTERS AND OTHER SITES

Submitted by

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In partial fulfillment of the requirements

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WE HEREBY RECOMMEND THAT THE DISSERTATION PREPARED UNDER OUR SUPERVISION BY KAY K STENERODEN ENTITLED A HOLISTIC APPROACH TO VETERINARY PUBLIC HEALTH IN ANIMAL SHELTERS AND OTHER SITES BE ACCEPTED AS FULFILLING IN PART REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY.

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ABSTRACT OF DISSERTATION

A HOLISTIC APPROACH TO VETERINARY PUBLIC HEALTH IN ANIMAL SHELTERS AND OTHER SITES

Animal health and human health are intimately linked. Directly, through contact with or exposure to animals and their environments, and indirectly by way of food production, food safety and antimicrobial drug residues, humans are dependent upon and vulnerable to the health of animals. Veterinary public health is concerned with the interface of human and animal health and addressing problems at that interface. The potential impact of such exploration is greater human and animal health.

Epidemiological needs assessment, problem investigation and subsequent outreach programs are essential tools of veterinary public health practice. These tools are used to explore infection control, infectious and zoonotic disease awareness, environmental contamination with infectious/zoonotic agents and monitoring the consequences of treatment of infectious and zoonotic diseases with antimicrobial drugs (i.e. antimicrobial drug resistance). The specific venues for these explorations for this dissertation include animal shelters, a veterinary teaching hospital, a former Soviet country and a United States governmental program.

A holistic approach is used with animal shelters to assess infection control and zoonotic disease awareness needs, investigate environmental contamination

with a zoonotic disease, develop training tools and train animal shelter workers and volunteers. The needs assessment provided valuable information on characteristics of animal shelters, provided impetus for the problem investigation and the basis for outreach training. The problem investigation tool provided the first available information on the prevalence and extent of salmonella contamination in Colorado animal shelters. The outreach components provided a tool and reference for training; the training itself indicated gaps in knowledge in various aspects of infection control and zoonotic disease awareness that could be addressed with training.

Further, problem investigation is explored through the success of active surveillance in discovery and control of a zoonotic disease outbreak in a veterinary teaching hospital. Results of a needs assessment survey in the Republic of Armenia provide the basis for development of outreach materials for veterinarians, farmers and school-age children on their national animal health program. And a system of antimicrobial drug resistance monitoring is examined and challenged for completeness.

Taken together, these studies further the examination of veterinary public health issues and highlight a holistic approach to their exploration.

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PREFACE

Animal health coexists, converges and often collides with human health - they are intimately linked. Directly, through contact with or exposure to animals and their environments, and indirectly by way of food production, food safety, and antimicrobial drug residues, humans are dependent upon and vulnerable to the health of animals. This relationship plays out every day with companion animals in animal shelters and in homes around the world; with livestock on intensive farms in developed countries or backyard flocks in the developing world; with wildlife on vast grassy plains in remote regions and in our own backyard bird feeders. The health of animals, large, small or wild is fundamental to our own.

Veterinary public health is concerned with the interface of human and animal health and addressing problems at that interface to the benefit of both humans and animals. Recognizing that human and animal health are inextricably linked, veterinary public health seeks to promote, improve and defend the health and well-being of all species. [1] The scope of veterinary public health is broad. It straddles the boundaries of veterinary medicine, human medicine and public health, epidemiology, and environmental health. Topics of consideration in veterinary public health include diagnosis, surveillance, epidemiology, control, and prevention of zoonoses, food safety, antimicrobial drug resistance, environmental health of animal environments, health education and extension; and management of domestic and wild animal populations.[1] Because veterinary public health is

[1] Revised from One Health mission statement http://onehealthinitiative.com/mission.php

concerned not only with food safety but also with the direct health of animals used for food (and therefore protein available for consumption), it has a role in combating global hunger and poverty.[2] Veterinary public health is multidisciplinary, bringing together veterinarians in government, non-government and private sectors, physicians, nurses, microbiologists, environmental specialists, sanitarians, food technologists, agricultural scientists, and para-veterinary staff who will contribute to the treatment, control and prevention of diseases of animal origin.

Understanding the complex issues relating to veterinary public health and offering realistic, effective and reliable solutions requires a broad approach. The first step is assessing the characteristics and needs of all persons interested, involved and affected by a veterinary public health issue and may include producers, consumers, community members, workers, funders, and governments. Scientific investigation follows to identify diseases or risk factors with field investigation, and diagnostic testing. Scientific awareness alone does not necessarily translate into effective action so outreach or training is required to bring the information to those interested and affected persons. Each of these aspects of inquiry and response (needs assessment, problem identification and outreach) are important epidemiological activities on their own, but to truly address a problem and make a lasting impact a comprehensive approach has the best chance of improving animal and human health. This comprehensive approach has been utilized in other methods of needs assessment, problem identification and outreach such as community based participatory research[3] and participatory epidemiology[4].

With this in mind, this dissertation will apply the epidemiological tools of survey/needs assessment, problem investigation and outreach to explore several veterinary public health issues in regional animal shelters, a veterinary teaching hospital, a transitional country and a governmental program. In the chapters that follow the holistic approach (needs assessment plus problem investigation plus outreach) is used in its entirety in the example of animal shelters. Other chapters are examples in one or more of these necessary components of assessing and addressing contemporary veterinary public health issues.

Animal shelter section

Chapter 2: Shelter needs assessment. This chapter was the first step in a series of projects to assess and address needs in animal shelters relating to infection control and zoonotic disease awareness. The objectives of this study were to identify and characterize regional animal shelter populations. The hypothesis was that disease concerns, training levels, training needs and desire for training would vary by geographical region and demographics. Specific aims included gathering information on shelter type, shelter size, species accepted, disease concerns and disease estimates, infection control practices, their desires for training and preferred methods of training. The results of this study provided valuable and needed information on the characteristics of animal shelters in the United States; provided impetus for the disease investigation carried out in Chapter 3 and provided the basis for the outreach conducted in Chapter 5.

Chapter 3: Environmental sampling for *Salmonella spp.* in Colorado animal shelters. This chapter uses the novel approach of environmental sampling to investigate a disease of unknown prevalence in animal shelters. The hypothesis of this study was that environmental contamination would vary by shelter type, geographical location, and species housed. Specific aims were to gather demographic information on Colorado animal shelters, determine the prevalence of environmental contamination with Salmonella, determine high and low risk areas within the animal shelters and determine high or low risk species. The results of this project provided the first available information on the prevalence and extent of salmonella contamination in Colorado animal shelters.

Chapter 4. Maddie's Infection Control Manual for Animal Shelter Workers This chapter contains the first two sections written for the Maddie's Infection Control Manual for Animal Shelters. The infection control manual was developed as a resource for veterinarians and veterinary students involved in animal shelter medicine. The purpose of the handbook is to enhance knowledge about infection control measures in the shelter environment, and to aid veterinary professionals in the development and implementation of infection control protocols.

Chapter 5: The effect of training on infection control and zoonotic disease awareness knowledge of animal shelter workers and volunteers This chapter culminates and rounds out the knowledge gained in Chapters 2 and 4 and uses that information to conduct outreach training on issues and in the manner requested by animal shelters. The paper discusses the changes in shelter workers' and volunteers'

knowledge of infection control and zoonotic disease awareness resulting from an education program. The hypothesis was that infection control and zoonotic disease awareness knowledge would change as a result of training. The specific aim was to provide training and perform pre and post training knowledge assessments.

Other sites section

Chapter 6: Report of surveys of Armenian veterinarians, farmers, teachers and the general public on preferences for outreach education information. This chapter combined the tools of needs assessment with outreach. Under the auspices of a program conducted through CSU and the USDA in the transitional country of the Republic of Armenia, veterinarians, farmers, the general public and teachers of school age children were surveyed to determine their needs and desires for outreach education on their national animal health program. The central hypothesis of this project was that needs and preferences for outreach would vary by group. Specific aims included surveying groups individually to ascertain their needs and preferences for information on their national animal health program and to tailor outreach to each group. The results of this project provided the basis for development of outreach materials for veterinarians, farmers, the general public and school-age children in Armenia.

Chapter 7: Outbreak investigation: Nosocomial *salmonella* in a veterinary teaching hospital, disease investigation and prevention measures. This chapter explores an outbreak investigation in a veterinary teaching hospital. The chapter focuses on problem identification/investigation; however, the incident itself

encompassed needs assessment (provided through positive environmental and animal salmonella test results) and outreach (to students, staff, clients and the general public). When routine environmental and animal testing for *salmonella* showed increased incidence of a single serogroup of *salmonella* investigation and outreach were initiated. Though not in the form of a questionnaire or survey, this routine passive monitoring for disease acted as a source of needs determination. Exploration of the problem is presented in detail in Chapter 7. What was not presented in the chapter was elaboration on the level and extent of outreach that was necessary to inform, educate, mobilize and allay the fears of students, staff, clients and the general public regarding this outbreak. Although the paper's focus is on outbreak investigation, addressing this veterinary public health issue clearly encompassed a holistic approach including the fundamental components of determining need, problem investigation and outreach. The hypotheses of this paper were that extensive patient and environmental surveillance and persistent mitigation efforts can be used to control a nosocomial salmonella outbreak without resorting to hospital closure. Specific aims included reporting on patient sampling, environmental sampling, isolation, disinfection and other mitigation efforts used in this disease outbreak to control and prevent disease spread.

Chapter 8: Antimicrobial resistance monitoring: review of data streams used in the U.S. system. This chapter straddles the categories of outreach and needs assessment. This chapter is intended as outreach to inform and stimulate discussion on the public health issues of the national antimicrobial drug resistance monitoring system (NARMS) in the United States. This chapter is also in part a needs

assessment, reporting on what the process of antimicrobial drug monitoring is, and taking it a step further and exploring and assessing needs for a better process. This paper was written to determine program needs and inform on policy in a changing environment.

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This dissertation is dedicated to my daughter

Ruby Nicole Shuna Steneroden

You are my sunshine

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Chapter 1: Literature Review

This section reviews current literature on survey and need assessments, environmental sampling, outreach education and animal shelters as they apply to veterinary public health and the issues addressed in this dissertation. The literature review enables us to understand the benefits and limitations of surveys, the processes and purposes of environmental sampling for biological contamination, the uses of outreach in veterinary public health education and the unique environment and issues relating to effective training in animal shelters.

Surveys and Needs Assessments

Data collection is an essential component of all epidemiological studies. Collection of data is often conducted through surveys, questionnaires, polls, telephone interviews, face-to-face interviews and needs assessments surveys. These methods require careful epidemiological design to satisfy the needs for the aims of a particular study.

Surveys are designed to attempt to assess knowledge, attitudes, beliefs, personal facts, memories[1] and can be used to ascertain a level of knowledge, in order to know where to begin or how to clarify and target outreach. [2] Self-administered surveys are useful for investigating attitudes and opinions that are not usually observable[3]. The strengths of self-administered surveys include their relative ease of construction and low cost; they are time saving, compared to face-

to-face interviews, for the survey developer as well as the respondent. However, this ease of construction has led to problems with mediocrity - it is relatively easy to construct a poor questionnaire but much more difficult to develop one that yields worthwhile data[4]. No other research methodology has been so much abused as the questionnaire.[4]

Developing good surveys involves art as well as science and begins with questions that are clearly worded, straightforward and necessary.[1 5] Because respondents can be anonymous they may give more honest responses than if they are in the presence of an interviewer [4] Surveys allow the gathering of information from many people very quickly and analysis of responses to closed-form questions is straightforward. Self administered surveys remove the possibility of interviewer bias[4], where different interviewers can get different answers from the same respondent. Questions should be ordered in a logical sequence – grouped by subject matter and formatted to be easy to follow. Good questions are framed at the level of understanding of the person taking the survey, i.e. at the education level and reading ability of those filling it out. [3] Surveys should be evaluated ('piloted') before being administered, typically by administration to a small audience similar to the target audience, to ensure that the survey is not too long, too detailed or unclear. [5]

The weaknesses of self-administered surveys include typically low response rates and the inability to correct misunderstood questions.[4] Predetermined answer choices are required (in closed question surveys) and may not fit respondents' answers. Literacy problems and reading disabilities may affect the ability of respondents to properly respond to a self-administered survey.[3] Data quality of

question-based mailed surveys may be poor. Surveys are often hastily and carelessly answered and the factual accuracy cannot be assumed. [4] Timing of surveys is important, especially in animal health studies where season often plays a role in disease. Surveys should be given at a time convenient to the respondents in order to obtain the best results. Even when timing is good, response rates will vary with surveys and are a potential source of bias.[5,6] One should report the total number of respondents asked to participate and not just those who responded. Mail surveys often produce only a 40-50% response rate[5] Response bias may occur when response rates are less than 70-80%.[5,6] With response rates less than 70% systematic differences between those that choose to respond and those who choose not to respond necessitate caution in interpretation of results. [5,6]

The precision, reproducibility or reliability in surveys is determined by asking the same question more than once or attempting to elicit the same answer with two different but similar questions.[5,6] Validity is the degree to which survey answers reflect the actual truth and can be thought of as the sensitivity and specificity of a question.[5] Validity is measured by comparing survey answers to direct observation or some other independent criterion[6] and thus surveys are best when they are used in conjunction with other methods; one approach is usually not adequate to answer real life questions. Evidence from a variety of methods or sources is also known as triangulation, and is the process of describing and analyzing situations using a variety of methods and types of data. [7] It is a way of cross checking data (direct observation, records or literature review, diagnostic test results, etc) by taking the results of one method and comparing them to the results

of a different method or existing data.[8] Results that support each other increase confidence in the findings.

In summary, a practical and reliable survey will have questions logically sequenced; will be at the appropriate knowledge level of the respondent; be of sufficient length to obtain information without being so long as to decrease interest and increase haste in response; be conveniently timed for convenience to the respondent and be piloted to a reliable target group.

Environmental sampling

Disease problems in animal facilities can be investigated through examining records, performing diagnostic tests on samples from animals as well as examining their environments (i.e. surfaces, feed, and water) for agents that may affect health.

Environmental sampling is the process by which environmental samples are collected and analyzed for the presence of a pathogen or particle of interest. Surface sampling is used to detect contamination of animal environments with pathogens or particles that have the potential to be transmitted to humans or animals. Environmental contamination can occur for example with a bacterial or viral pathogen when it is spread throughout a facility by animal or human traffic.

The food, human and veterinary industries are particularly interested in bacterial and viral contaminants in the environment. In addition to bacterial and viral pathogens, environmental health researchers may also be interested in heavy metals such as lead, or dust, pollen, and molds. The best technique for sampling an environment will vary with the type of organism that is sought. The food industry in the USA has the most sophisticated system for risk based management of

cleanliness.[9] Government regulations have forced the food industry to develop and maintain polices to protect the population from food borne illness. Human hospital and veterinary facility surface sampling standards are based on those used in the food industry, but have no government involvement or regulation.

The ideal sampling method will vary depending on climate, and surface, e.g. whether one is sampling a plastic cutting board, a waiting room chair or a conveyor belt in a poultry slaughter house.[10,11] Pathogen persistence on environmental surface (and thus the ability of any sampling method to detect it) is affected not only by the surface type but the ambient temperature and moisture conditions[12] The hand pump vacuum method may be best to test for molds in a water damaged home, whereas rodac plates or dip slides may be the best method for collecting MRSA on a hospital countertop,[13] and swiffers may be the best method for bacteria collection in a veterinary teaching hospital barn.[14] Different sampling methods are conducive to different sizes of sampling areas. Electrostatic wipes will allow for much greater coverage of a surface area in a salmonella contaminated veterinary hospital than a rodac plate or sampling swab which would only be able to cover and thus report on a fraction of that square footage.

Some methods give quantitative results (i.e. rodac plates) and some methods give qualitative results (i.e. electrostatic wipe). The program under which the sampling takes place may dictate the desired sampling method and data outcome. Quantitative methods may be desired for identifying problem areas or assessing bacterial load reduction. Qualitative methods such as the swiffer method give

results on the presence or absence of the contaminant and give no information on the number of organisms recovered.

Surface sampling is used to identify and thus protect humans and/or animals from serious health risks. Some risks might be considered more important than others and necessitate more directed approach or a change in approaches when a methods appears to be lacking. For example, routine sampling of vegetable rinsing area in a food preparation facility with swabs might be increased to rodac plate sampling of the entire facility after an outbreak of *e.coli* in pre-washed spinach in a food processing plant.

The methods utilized in the problem investigation section of this dissertation include traditional bacteriological testing for salmonella in feces as well as surface sampling with electrostatic wipes for salmonella. With wipe sampling, a gloved hand holding a 6x6 inch soft cloth-like electrostatic wipe is passed over surfaces with hand contact such as door knobs, keyboards, telephones, medical instruments, chairs, desks, etc. or is attached to a swiffer broom to sample floor and wall surfaces.[14] The cloths are put into individual sterile whirlpaks and cultured in the laboratory.

A main advantage of electrostatic wipe sampling is the simplicity of the sample collection; this method requires little technical knowledge to collect the sample. However, analysis of the sample for *Salmonella* requires trained laboratory staff and extensive use of a multitude of media.[14] The culture method requires viable bacteria. Immediately after collection, samples are put into enrichment media which enhances their viability with little time or opportunity for desiccation. Bacterial recovery using electrostatic wipes appears to be very good, but no studies validate

the swiffer method or compare it to any other surface sampling methods. Therefore, the sensitivity or specificity of the electrostatic wipe sampling method is not available. Electrostatic wipes have also been used in homes by residents to check for levels of household endotoxin. [15] Again the sampling is very simple, with the laboratory steps being quite detailed. One of the greatest advantages to swiffer sampling is the large surface area that can be sampled. Especially in cases where contamination is low and surfaces may be irregular maximizing the amount of surface sampled will lead to greater chance of recovery of the target organism. [16]

No one sampling method can completely characterize bacterial contamination on surfaces.[9] Different industries – environmental health, food industry, human health hospitals and the veterinary medical community – each have different motivations, requirements, and policies for pursuing surface sampling. Surface sampling encompasses many different techniques and methods depending on the policies and requirements of the industry doing the sampling, the type and extent of the surface being sampled, the expected organism, laboratory capability and capacity, the need to quantify results and the degree of health risk to animals and/or to humans.[17]

Training and Outreach

Outreach is an effort to distribute ideas or practices from one group to another and describes a variety of activities that extend information beyond the limits of the university. "Training", "intervention", "adult education", "educational intervention", "health education intervention", "knowledge-dissemination

interventions", "knowledge transfer", "community-based health-education intervention" are all terms used to describe these types of activities.

Much of the research in knowledge-dissemination involves outreach in developing countries. Methods have included individual and community training[18-20], video [21,22], drama [18], posters [20], visual aids in general [23] leaflets, [18] diagrammatic handouts [19] and various combinations of methods [18,19] some of which suggest that a multi-method approach enhances learning [18,24]. Short and long term results of knowledge dissemination methods have been examined in smallholder dairy farms in Tanzania[25], on cysticercosis reduction in Tanzania, [26] and on changes in disease management practices and illness after training farmers in rational drug use in Mali[27]. Although having reference material distributed and available for later reflection has been shown to be beneficial in some studies, [19] other studies on changes in mastitis management practices in the United States show that knowledge dissemination only – without training and ongoing training – to be ineffective. [28] An education intervention on dog sterilization and retention in Taiwan showed a negative effect of education on pet retention however, the effect was reversed after a period of time. [29] Research shows many different knowledge-dissemination methods have been used for educating individuals on human and animal health related matters, with varying results and success.

Outreach is often educational in nature but can also be viewed as a two-way street, a process where both sides learn from each other, an engagement with the community. The most effective outreach tools recognize the two-way nature of

communication.[30] Those who are directly involved and whose lives are affected by public health and veterinary public health issues may be best placed to describe and analyze problems in their own environments.[8]

Developing training materials and documents for outreach for this dissertation involved broad exploration of adult education concepts and practices,[31] instructional development and design concepts, [32,33] and health communication practices.[34] The underlying goal of all these efforts is the acquisition of knowledge and behavior change. When training shelter workers on infection control and zoonotic disease for example, adoption of personal protective practices and improving shelter infection control policies are desired changes which are anticipated to result in decreased human and animal disease.

Animal shelters

Animal shelters began with the impounding of roaming livestock in colonial times.[35] The development of the American Society for the Prevention of Cruelty to Animals (ASPCA) in 1866 is the beginning of animal protection and concern for treatment in animal shelters. [35] In the past as well as today animal shelters are often supported by concerned local citizens and sometimes local municipalities. While national animal shelter groups such as the Humane Society of the United States (HSUS) and the American Humane Association (AHA) exist as informational entities, animal shelters maintain their local structure and management with little or no national oversight. With urbanization and evolution of a pet owning public animal shelters have become community facilities with a variety of services. Animal

shelters today range from rescue groups that house a few animals a year[36] to major city facilities where thousands of animals pass through yearly[37]. Some provide no other services than impounding[38] of strays and/or relinquished animals, some provide full spay and neuter services for the shelter as well as surrounding community [39].

Much is unknown about animal shelters and their animals in the U.S. The actual number of animal shelters in the USA along with the number of animals entering and leaving (by various means of euthanasia, adoptions, reclaimed by owner) is not available.[40] The American Humane Association estimated in 1990 that there were between 3,000 and 5,000 animal shelters with 16.3 to 27.1 million cats and dogs entering these shelters each year with an estimated 11.1 to 18.6 million animals euthanized.[41]

Animal shelters vary tremendously in their size, facility, budgets, numbers of employees and volunteers, as well as level of training. Most shelters have high turnover of volunteers and employees, so that even those with adequate training may not have staff well informed on infection control at all times. Shelter work can be very stressful work, having to deal with unwanted animals and euthanasia leads to stress and job burnout. The age and education level of shelter employees and volunteers may vary greatly from high school students looking for animal experience to college educated managers, directors and veterinarians and retired persons volunteering their time. Shelters may also have foster care programs that have participating families with small children and/or older relatives in the home.

This variety in age, education level and level of involvement of those in shelter work makes development and delivery of effective training difficult.

The safety of workers and volunteers in animal shelters falls under federal regulation by the Occupational Safety and Health Administration (OSHA). However, there is variability in knowledge of and compliance with OSHA standards in animal shelters. OSHA guidelines most at issue in animal shelters result from the use of chemicals for cleaning and disinfection – the proper labeling of chemical containers, maintenance of material Safety Data Sheets (MSDS) and training programs that address the safe use of these chemicals. Other areas of concern to shelters include ear protection for kennel workers and personal protection against blood-borne pathogens with exposure to human blood,

Given the volume and density of animals, control of disease spread can be a major problem in animal shelters.[42] Fighting the spread of disease is one of the most frustrating, time consuming and costly jobs in animal shelters. [43,44] Animal shelter animals, workers and volunteers are a potentially vulnerable population whose exposure to zoonotic diseases may be greater than the general population. Because of the volume of animals with unknown histories encountered on a daily basis, shelter workers and volunteers may experience greater exposure to zoonotic diseases. With a great number of diseases shared between humans and animals, both human and veterinary medical communities are concerned about zoonotic disease and zoonotic disease awareness. Many of these diseases, such as rabies, leptospirosis, anthrax, and ringworm, have been around for hundreds of years, where others such as SARS and monkey pox are new and emerging. Individuals in

contact with animals are at greater risk of contracting a zoonotic disease. Knowledge of zoonotic diseases, their clinical signs, methods of spread and good infection control practices can help reduce the risk of disease in both human and animal populations.

This dissertation will discuss several contemporary veterinary public health situations and will apply the epidemiological tools of needs assessment, problem identification and outreach to explore them.

An extensive appendix which includes surveys, training and outreach materials is provided.

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Chapter 2: Infection control and zoonotic disease awareness in animal shelters: Needs assessment and demographic survey

Introduction

Animal shelters are facilities that house lost or abandoned animals until they are reclaimed, adopted, transferred or euthanized. Animal shelters began with the impounding of roaming livestock in colonial times.[1] In the past as well as today animal shelters are often supported by concerned local citizens and sometimes local municipalities. Although national animal shelter groups such as the Humane Society of the United States (HSUS) and the American Humane Association (AHA) exist as informational entities, animal shelters maintain their local structure and management with little or no national oversight.

Animal shelters in the United States and worldwide vary tremendously in their size, intake, facility, budgets, oversight, personnel, and training. Animal shelters today range from rescue groups that house a few animals a year [2] to major city facilities where thousands of animals pass through yearly.[3] Some provide no other services than impounding of strays and/or relinquished animals [4], some provide full spay and neuter services for the shelter as well as surrounding community. [5] This variety adds to the difficulty in characterizing animal shelters. While millions of animals (mostly dogs and cats) enter these facilities each year, information on basic shelter characteristics and disposition of their animals is lacking. Data on such characteristics as the number of animal shelters in the country, the number of animals entering and leaving, the number euthanized, and

the number adopted is not available.[6] Progress is being made; research into the nature of animal shelters is increasing but it must continue for animal shelters and their funders to determine their programs' efficacy and whether they are allocating resources wisely. [6]

Infectious and zoonotic disease control are a major problem in animal shelters [7] where newly introduced animals may carry a variety of pathogens, stressed animals are more vulnerable to infection, and crowded and less than excellent hygiene conditions promote the spread of disease. [8,9] Infectious disease outbreaks of feline upper respiratory disease, for example, are a common problem dealt with on a regular basis in the country's animal shelters.[10,11] Risk of outbreak and exposure to zoonotic pathogens such as *salmonella spp.*, methicillin-resistant staphylococcus aureus, and *leptospira spp.* is largely unknown. The level of knowledge and awareness by shelter staff and volunteers of these diseases is also largely unknown.

Shelters are primarily staffed with lay people whose medical training and experience vary greatly. Because of the nature of animal shelters and animal shelter work, the volume of animals with unknown histories encountered/handled on a daily basis, shelter animals, workers and volunteers are a potentially vulnerable population who may experience greater exposure to zoonotic diseases than the general population. Knowledge of infection control principles and practices, zoonotic diseases, their clinical signs and methods of spread can help reduce the risk of disease in both human and animal populations.

Surveys are data collection tools that can be used to gather demographic information as well as assess knowledge, attitudes, and beliefs.[12] Surveys help identify areas in need of further investigation and can help clarify outreach efforts.[13] A needs assessment survey was determined to be the best method to obtain information on the characteristics of animal shelters, to determine perceptions on the levels of infectious and zoonotic disease and assess needs and desires for training.

The objectives of this study were to identify and characterize the demographics of animal shelters in a 6-state region through a needs assessment survey and to assess disease control and knowledge information to direct future training efforts. The hypothesis was that disease concerns, training levels, training needs and desire for training would vary by geographical region and demographics. Specific aims included gathering information on shelter type, shelter size, species accepted, disease concerns and disease estimates, infection control practices, shelter desires for training and preferred methods of training.

Methods

Study population: Animal shelters in Colorado, Wyoming, Utah, Montana, North Dakota and South Dakota were identified through internet searches of animal shelters, animal rescue organizations, and animal sanctuaries. Only organizations with a physical shelter facility were included in the sampling frame. One hundred fifty four (154) shelters in the six states were identified.

Shelter Needs Assessment survey: A 66 question needs assessment survey was developed which focused on four areas: demographic information, infectious

and zoonotic disease concerns and perceived levels, infection control policies and worker training levels including desire for training. The survey was pilot tested at an animal shelter not included in the study. Response choices were limited to specified response choices or based on a Likert scale (1-3 or 1-4). Likert scale results were reported as averages (i.e. 1.5/4 or 2/3). Surveys were mailed out to shelters; those not responding within two weeks were sent an additional letter and survey; those not responding within 2 weeks were mailed a third letter and survey. No further attempts were made to contact non-responding shelters.

Analysis: Surveys were entered into an Access[i] database and analyzed using SPSS [ii] and STATA [iii]. Relationships between categorical and Likert-scale data were analyzed for overall significance using Kruskall-Wallis [14] and post hoc paired comparisons made with Wilcoxon sign rank test [15] and significance values adjusted with Holm's sequential Bonferroni. [16] Statistical significance level for this study was <0.05.

Results

Shelter demographics/study population: Survey responses were received from 78/154 (50.6%) of animal shelters who were mailed surveys. (Table 1) The majority of shelters that responded to our survey were open-admission shelters (48%). (Table 1) The median animal intake of responding shelters per year was 780 animals (range 7 -28,000 animals). The majority of animals coming into shelters were stray (46%) or relinquished by their owners (31%). (Table 1)The median number of full time staff of responding shelters was 3 (range 0-120), part time staff 2 (range 0-30), and volunteers 5 (range 0-600). The median estimated annual

budget of shelters in our study population was $122,500 with a range $500 to $10 million dollars. Approximately 90% of study shelters accepted both cats and dogs. One third of shelters accept livestock and wildlife species. (Table 1) The overall adoption rate for shelters was 58.5% (range 5-100%) and euthanasia rate was 16.6% (range 0-60%). (Table 1) Forty-five percent (45%) of shelters reported that many to most animals arrive with infectious disease already present. Other concerns upon arrival include dental disease, malnutrition, skin conditions, geriatric and pediatric concerns, and injury. (Table 1)

Awareness and concern over infectious and zoonotic diseases: The three infectious diseases of most concern in shelter animals were feline upper respiratory disease, canine parvovirus and feline panleukopenia (Table 2). Diseases of least concern in animals included plague, leptospirosis and canine distemper. (Table 2) Zoonotic diseases of most concern to shelters and workers included fecal parasites, ringworm and kennel cough (Table 3). Zoonotic diseases of least concern to shelters included plague, emerging diseases, tularemia, psittacosis and leptospirosis. (Table 3)

Level of infectious and zoonotic diseases and ability to identify disease: Overall, shelters reported a low to moderate level of infectious disease in their shelters with the highest level of disease being feline upper respiratory infection. (Table 4) Overall, shelters reported a low to no level of zoonotic diseases in their shelters. (Table 4)

Staff and volunteer training on infection control: When infection control training occurred it was most often upon hiring of staff (96% of the time) and

volunteers (88% of the time). Eight to 12 percent (8-12%) of shelters offered training to both staff and volunteers on a yearly basis and 60% of shelters offered training to both staff and volunteers intermittently, when problems arose. Fifty-one percent (51%) of those responding to the survey had received some type of training on infection control through their shelter. Sixty-one percent (61%) of shelters discussed potential disease transmission to humans in these training sessions. Fifty-seven percent (57%) of shelters informed individuals with animal contact of increased risk of zoonotic disease if they were in any way immune compromised. Written materials, in person training and on the job training were regarded equally as methods of training shelter workers (62-68% chose all 3). Sixteen percent (16%) of shelters chose on-line materials as a method that would work well in their shelters and 51% said a combination of methods works best to train shelter workers. Ninety percent (90%) of shelters said they would benefit from training in infectious disease, 88% would benefit from training in zoonotic disease and 74% would benefit from training in cleaning and disinfection. Nine percent (9%) of shelters said they did not need any additional training.

Staff and volunteer training on infectious and zoonotic diseases: Fifty to seventy percent (50-70%) of shelters report that they trained most of their staff on the clinical signs, modes of transmission, and actions to be taken when infectious/contagious disease is discovered (Table 5). Approximately 30% of shelters offered no training to volunteers on infectious diseases (Table 5). Thirty seven to fifty one percent (37-51%) of shelters reported that they train most of their staff on the clinical signs, modes of transmission and actions to be taken when

zoonotic disease is discovered. In approximately 50% of shelters no training was offered to volunteers on zoonotic diseases (Table 5).

Diagnostic tools: Diagnostic tools and tests most commonly used in shelters include microscopes (57%) fecal testing (57%) and blood testing (e.g. felv, fiv tests) (59%) (Table 6).

Isolation: Ninety percent (90%) of shelters reported having a separate isolation area for confining suspect and confirmed contagious disease cases. Ninety two percent (92%) of shelters restricted the general public from visiting patients in isolation and 82% (61/74) had a separate exercise area for isolation patients to relieve themselves. Some level (average Likert value 1.89/3) of training was provided to volunteers on appropriate barrier protection (e.g. gloves, gown, boots and mask use in isolation); staff received a greater degree of training (average Likert value 2.4 out of 3). Equipment and supplies were often (average Likert value 3.16 out of 4) dedicated solely to isolation while footbaths were only sometimes (average Likert value 2.07/4) used. Running out of space in isolation (Likert scale 1=never, 2=sometimes, 3=often) had an average Likert value of 2.3/3 with cat cages and 1.81/3 with dog cages.

Communication with the public: Shelters used a variety of methods to communicate policies regarding animal handling, visitation and health of adoptable animals. Ninety two percent (92%) of shelters verbally communicated with the adopting public when potential adopters enter the shelter; 58% have attendants in animal rooms who verbally communicated policies and, 52% used signs to inform the public. Five percent had no method of communication with potential adopters

on animal handling. In animals adopted out with, or recovering from, infectious disease, adopters were almost always (average Likert value 3.91 out of 4) informed of potential risk of disease transmission to their pets at home. Many shelters reported that they do not adopt out/or send home animals with zoonotic diseases. If animals with zoonotic diseases are sent to an adopter's home, the adopters were usually (average Likert value 3.73/4) informed of potential risk of disease transmission to themselves or their family members.

Variables relating to infection control activities: In 39% of shelters the job of infection control was shared among two or more individuals. No one was in charge of infection control in 8% of shelters and 5% of infection control oversight was by veterinarians alone. Thirteen percent (13%) of shelters had a written infection control manual. Seventy-four percent (74%) of shelters had a written cleaning and disinfection protocol and 86% of shelters that had C&D protocols offered worker training on cleaning and disinfection. Thirty-nine percent (39%) of shelters spent from $0-100 per month on disinfectants, 30% spent between $100-200, 14% spent between $200-300 and 17% spent in excess of $300 per month on disinfectants. Fifty-eight percent (58%) of study shelters had a written protocol on preventive medicine for animals which included vaccination, de-worming, and disease testing policies. Thirty four percent (34%) had policies but they are not written. In animals that are kept for extended periods of time, 81% of shelters had a revaccination schedule. Ninety two percent (92%) of shelters de-wormed animals and 74% had a schedule for repeat de-worming if animals were kept for an extended period of time.

Specific written disease policies for diseases of great concern (e.g. a written policy of how a shelter will handle an outbreak of parvo or a suspect case of rabies, etc.) existed in 26% of shelters; in the remainder of shelters policies for each disease case or outbreak were decided on an individual basis. In the current study, shelter staff and volunteers were often (3.1 out of 4) observed washing their hands after animal contact. Thirty two percent (32%) of shelters restricted eating and drinking in areas where animals were present. A separate refrigerator not used for biological specimens or vaccines was provided for staff and volunteer meals in 70% of shelters. Uniforms were required for staff in 37% of shelters and for volunteers in 12% of shelters. In 13% of shelters, staff and volunteers were asked to bring in a change of clothing to work in. Forty-seven percent (47%) of shelters allowed staff and volunteers to wear whatever they want.

Staff and volunteer health records were maintained in many shelters with 83% maintaining emergency contact information, 31% maintaining rabies vaccination information and 34% tetanus vaccination status. (Table 6)

Overall level of infectious disease reported by animal shelters differed significantly by annual animal intake, annual budget, and number of full time staff, with higher overall levels of infectious disease associated with higher animal intake, higher annual budget and greater number of full time staff (Table 7). Overall level of infectious disease was also significantly associated with shelter admission type with open admission shelters having higher overall levels of infectious disease than no-kill or rescue/sanctuary type facilities.

Discussion

The information gained from this needs assessment survey adds to the growing body of literature on U.S. shelters and their characteristics. Specifically this survey of shelters in Colorado, Montana, Wyoming, Utah, North Dakota, and South Dakota represented over 150,000 animals including 69,000 strays, and 46,500 owner relinquished animals. Given the results of this current study, approximately 88,000 of those animals were adopted to new owners, 11,700 were returned to their owners and 24,900 were euthanized with over 29 million dollars per year expended for their care. These shelters represented approximately half of the animal shelters in the 6-state region.

The identification of feline upper respiratory disease as disease of greatest concern was not surprising. Previous studies have shown feline upper respiratory disease to be a disease of great concern while an animal is a shelter resident [11] and post adoption. [17] There was a very low level of concern for several serious zoonotic diseases that occur in the region including plague, tularemia, leptospirosis, and salmonella. This low level of concern is likely due to lack of awareness of these diseases, their clinical signs and their potential presence in animal shelters.

Numerous studies have acknowledged or identified relevant factors other than disease organism or host factors to be important in disease transmission. These relevant factors fall under the category of infection control and include the ability to isolate affected animals [11,18] fomite spread of disease [18,19 20] inappropriately performed disinfection [21], less than excellent hygiene and crowding [9], days in the shelter [11] , contact with/close proximity to dogs [11,22] and factors

intrinsic to the shelter environment .[23] In the current study the majority of shelters (74%) had a written protocol on cleaning and disinfection. Fewer shelters had written preventive medicine protocols (58%) or specific disease protocols (26%) and very few had infection control manuals (13%). Written protocols and policies raise awareness of shelter standards and expectations, remove doubt and provide for faster response and decision making in outbreak situations, and can be used as a learning tool for new staff and volunteers. Assistance with written protocol development would be beneficial to animal shelters in the study region.

It is difficult to maintain infection control policies and procedures without an adequately trained staff. Only a small percentage of shelters in this study (10%) trained workers on infection control on a yearly basis. High turnover of both staff and volunteers necessitates the institutionalization of training in animal shelters on the basics of infection control, personal protection and zoonotic disease awareness. Volunteers are particularly under-trained and under-utilized with approximately half of shelters offering no training to volunteers on zoonotic diseases. Ideally, training levels should increase for all workers, staff and volunteers to better meet infection control needs.

Increased overall perceived level of infectious disease was associated with annual animal intake, annual budget and number of full time staff. These predictor variables are indicative of shelter size. It is biologically plausible that the greater all of these variables are the more likely overcrowding is an issue at the shelter – leading to increased levels of disease. However, no effort was made in the current study to quantify density of animals in their environments. Increased population

density has been shown to increase the prevalence of URI [9,24]. Shelter admission type was also significantly associated with overall perceived level of infectious disease. Stability of the populations may be a likely explanation. Open admission shelters are continuously adding new animals on a regular basis to their populations. No-kill and rescue type facilities because of the limits of space must limit the introduction of new animals and therefore limit the introduction of disease. Other shelter studies have found URI tended to increase and stay elevated in traditional (open) shelters while in no-kill shelters, URI tended to peak at 21 days post admission of new animals, and then decline. [11]

An objective of this study was to identify and characterize shelters in order to direct future training efforts. The observation of increased perceived levels of disease in larger shelters will not affect the choice of shelters for inclusion in the shelter worker training project.

Shelters in the current study varied in facilities, funding, animal intake, and numbers of personnel. Including the needs of all types, sizes and shapes of animal shelters in developing outreach and training is important. Shelters that receive 7 animals per year will have different needs than shelters that receive 28,000 animals per year, but both will encounter infectious and zoonotic disease, need to perform infection control to protect themselves and their animals from disease spread, and need training for their workers and volunteers. Because the vast majority of shelters responded that training in infectious disease, zoonotic disease and cleaning and disinfection would be beneficial, training will be developed and delivered in all types of shelters, large and small.

Limitations of the study include the potential for response bias. Response rates less than 70% necessitate caution in interpretation of results as there may be systematic differences between those that chose to response and those who chose not to respond. [25,26] To increase response rate the mailing of surveys was timed to coincide with the slower period in animal shelters of late winter to early spring. Small shelters with fewer employees might be less likely to respond for lack of manpower. If smaller shelters did not respond and were underrepresented in our study, our results would overestimate the perceived level of infectious disease. If larger shelters did not respond our results would likely underestimate perceived level of infectious disease

This needs assessment survey adds to the growing body of shelter related studies and helps characterize animal shelters in the United States. This study is the first step in a series of projects to assess and address needs in animal shelters relating to infection control and zoonotic disease awareness and will help guide the development of shelter worker and volunteer training.

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Tables

Table 2.1. Self-reported demographic descriptors from 78 animal shelters in Colorado, Wyoming, Utah, Montana, North Dakota and South Dakota			
Variable	**Category**	**Number (percent)**	
Total responses		78/154 (50.6)	
Response by state			
	Colorado	31/65 (47.7)	
	Montana	21/37 (56.8)	
	North Dakota	5/8 (62.5)	
	South Dakota	6/12 (50.0)	
	Utah	8/22 (36.4)	
	Wyoming	7/13 (53.8)	
Person completing survey			
	Shelter director	40/78 (51.2)	
	Shelter manager	25/78 (32.1)	
	Kennel manager	11/78 (14.1)	
	Full time veterinarian	9/78 (11.5)	
	Consulting veterinarian	2/78 (2.6)	
	Part-time veterinarian	8/78 (1.3)	
	Other: including animal control officer, veterinary technician, interim directors, volunteer veterinarian, founder, finance director, and director of operations.	16/78 (20.5)	
	Average length of time working at shelter	7.5 years	
	Average time in current position	6.5 years	
Shelter admission type			
	Open admission	37/73 (50.7)	
	Limited admission	11/73 (15.1)	
	No-kill	20/73 (27.4)	
	Rescue/sanctuary	5/73 (6.9)	
Record keeping			

Table 2.1 continued			
	Shelters with computerized data systems	49/77 (63.6)	
	Shelters that keep medical records on animals	71/78 (91.0)	
Annual intake	Median annual intake	780	Range 7-23,500
Annual budget	Median estimated annual budget	$122,000	Range $500 - 10million)
Full-time staff	Median number of full time staff	3	Range 0 - 120
Part-time staff	Median number of part-time staff	2	Range 0-30
Volunteers	Median number of volunteers	5	Range 0 - 600
Source of animals			
	Stray	(58.7)	
	Owner relinquishment	(31.0)	
	Transfer from local shelters	(3.5)	
	Transfer from out of state shelters	(1.8)	
	Other: born at shelter, owner arrest, seizure, bite hold	(6.4)	
Disposition of animals	Adopted to new owner	(58.6)	Range 5-100%
	Reclaimed by owner	(17.8)	Range 0-55%
	Euthanized	(16.6)	Range 0-60%
	Transferred	(5.1)	Range 0-50%
	Died in shelter	(1.1)	Range 0-10%
Shelters accepting species			
	Cat	69/76 (90.8)	
	Dog	67/75 (89.3)	
	Small mammals	50/76 (65.8)	
	Birds	47/76 (61.8)	
	Reptiles	36/76 (47.3)	

Table 2.1 continued			
	Amphibians	27/75 (36.0)	
	Pigs	22/75 (29.3)	
	Wildlife	22/75 (29.3)	
	Horses	21/75 (28.0)	
	Small ruminants	20/73 (27.4)	
	Other (donkey, fish, ruminants)	10/73 (3.0)	
Shelters responding that many to most animals arrive with these health conditions			
	Dental concerns	35/77 (45.4)	
	Infectious disease	35/78 (44.9)	
	Malnutrition	27/78 (34.6)	
	Geriatric concerns	26/78 (33.3)	
	Pediatric concerns	22/78 (28.2)	
	Skin conditions	14/78 (18.0)	
	Chronic disease	8/78 (10.3)	

Table 2.1A. Numerical designation of responses for Likert scale categorization for Tables 2-5				
	Likert Scale			
Category for Likert Responses	**1**	**2**	**3**	**4**
Table 2.2. Self-reported level of concern of infectious diseases in animals from 78 animal shelters in Colorado, Wyoming, Utah, Montana, North Dakota and South Dakota	No concern	Slight concern	Moderate concern	Great concern
Table 2.3. Self-reported level of concern of zoonotic diseases to workers from 78 animal shelters in Colorado, Wyoming, Utah, Montana, North Dakota and South Dakota	No concern	Slight concern	Moderate concern	Great concern
Table 2.4. Self-reported perceived level of infectious and zoonotic diseases and comfort with ability to identify diseases from 78 animal shelters in Colorado, Wyoming, Utah, Montana, North Dakota and South Dakota	Low	Moderate	High	
Table 2.5. Self-reported level of training offered by shelters to staff and volunteers on infectious and zoonotic diseases (%) from 78 animal shelters in Colorado, Wyoming, Utah, Montana, North Dakota and South Dakota	No training received	Some receive training	Most receive training	

Table 2.2. Self-reported level of concern of infectious diseases in animals from 78 animal shelters in Colorado, Wyoming, Utah, Montana, North Dakota and South Dakota

Disease	No concern	Slight concern	Moderate concern	Great concern	Percent responding
Feline URI	8.0	10.67	30.67	50.67	75/78
Feline panleukopenia	14.47	26.32	35.53	23.68	76/78
Ringworm	9.21	34.21	32.89	23.68	76/78
Plague	43.24	41.89	6.76	8.11	74/78
Kennel cough	14.47	30.26	31.58	23.68	76/78
Canine influenza virus	19.18	28.77	32.88	19.18	73/78
Canine distemper	16.44	36.99	24.66	21.92	73/78
Canine parvovirus	9.33	18.67	30.67	41.33	75/78
Leptospirosis	36.23	37.68	18.84	7.25	69/78
Internal parasites	11.69	23.38	42.86	22.08	77/78
External parasites	12.99	35.06	32.47	19.48	77/78

Table 2.3. Self-reported level of concern of zoonotic diseases to workers from 78 animal shelters in Colorado, Wyoming, Utah, Montana, North Dakota and South Dakota

Disease	No concern	Slight concern	Moderate concern	Great concern	Number responding
Plague	49.30	32.39	12.68	5.63	71/78
Tularemia	59.15	28.17	8.45	4.23	71/78
psittacosis	59.15	25.35	11.27	4.23	72/78
Avian influenza	56.94	26.39	12.50	4.17	72/78
Kennel cough	16.67	36.11	26.39	20.83	72/78
Emerging diseases	54.17	33.33	9.72	2.78	72/78
Leptospirosis	45.71	31.43	17.14	5.71	72/78
Fecal parasites	17.81	16.44	52.05	13.70	73/78
Ringworm	7.04	35.21	36.62	21.13	71/78
Sarcoptic mange	18.06	45.06	29.17	9.72	72/78

Table 2.4. Self-reported perceived level of infectious and zoonotic diseases and comfort with ability to identify diseases from 78 animal shelters in Colorado, Wyoming, Utah, Montana, North Dakota and South Dakota		
		Average Likert value
Level of infectious diseases		
	Canine influenza virus	1.2/3
	Canine distemper virus	1.2/3
	Feline URI	2.2/3
	Kennel cough	1.7/3
	Canine parvovirus	1.4/3
	Feline panleukopenia	1.3/3
	Internal parasites	1.9/3
	External parasites	1.5/3
	Kitten diarrhea	1.9/3
Perceived overall level of infectious diseases		1.5/3
Comfort with ability to identify animals with infectious disease		2.5/3
Level of zoonotic diseases	Avian influenza virus	0.8/3
	Campylobacter	0.7/3
	Leptospirosis	0.8/3
	Lyme disease	0.9/3
	Plague	0.7/3
	Psittacosis	0.6/3
	Salmonella	0.8/3
	Sarcoptic mange	1.1/3
	Ringworm	1.5/3
	Tularemia	0.7/3
	Internal parasites	1.6/3
Perceived overall level of zoonotic diseases		1.1/3
Comfort with ability to identify animals with zoonotic disease		2.1/3

Table 2.5. Self-reported level of training offered by shelters to staff and volunteers on infectious and zoonotic diseases (%) from 78 animal shelters in Colorado, Wyoming, Utah, Montana, North Dakota and South Dakota					
Training type	**Training content**	**Staff or volunteer**	**None receive training**	**Some receive training**	**Most receive training**
Infectious disease					
	Clinical signs of disease	Staff	5.48	42.27	52.05
		Volunteer	33.8	49.0	17.65
	Actions to take when disease discovered	Staff	0	31.51	68.49
		Volunteer	32.35	26.76	30.88
	Mode of transmission	Staff	1.37	39.73	58.9
		Volunteer	27.94	42.65	29.41
Zoonotic disease					
	Clinical signs of disease	Staff	13.7	49.32	36.99
		Volunteer	50.0	41.4	10.61
	Actions to take when disease discovered	Staff	10.9	38.36	50.68
		Volunteer	48.48	36.36	15.15
	Mode of transmission	Staff	9.59	45.2	45.21
		Volunteer	45.31	40.63	14.06

Table 2.6. Self-reported variables related to infection control activities from 78 animal shelters in Colorado, Wyoming, Utah, Montana, North Dakota and South Dakota		
Variable	**Category**	**Number (percent)**
Tools and tests available for use by shelters	Microscope	40/70 (57.1)
	Centrifuge	25/69 (36.2)
	Fecal testing	40/70 (57.1)
	Blood testing (e.g. FELV)	41/70 (58.5)
	Blood panel-in house	7/66 (10.6)
	Blood panel-send out	31/70 (44.3)
	Urine dipstick	25/66 (37.9)
	Urine cytology	18/69 (26.1)
	Stains	23/70 (32.9)
	Radiographs	16/70 (23.9)
	Woods lamp	32/69 (46.4)
Individuals designated in charge of infection control at the shelter		
	Two or more individuals	23/78 (29.5)
	Shelter Director	18/78 (23.1)
	Shelter Manager	15/78 (19.2)
	Other: Vet tech, director of operations, shelter attendants, "all employees, and animal control officer.	11/78 (14.1)
	No one is in charge of infection control	6/78 (7.7)
	Veterinarian	5/78 (6.4)
Number of shelters vaccinating cats and dogs with specific vaccines		
	Canine: DHLPP,DHPP or DA2PP	43/67 (64.2)
	Canine: Rabies	30/66 (45.5)
	Canine: Bordetella	43/66 (65.1)
	Feline FVRCP	57/67 (85.1)
	Feline: FELV	14/63 (22.2)
	Feline: FIV	5/60 (8.3)
	Feline: Rabies	28/63 (44.4)

Table 2.6 continued		
Shelters that maintain employee health record information		
	Staff Emergency contact information	59/68 (86.8)
	Volunteer emergency contact information	33/67 (49.3)
	Staff rabies vaccination information	22/71 (31.0)
	Volunteer rabies vaccination information	6/67 (9.0)
	Staff tetanus vaccination information	24/71 (33.8)
	Volunteer tetanus vaccination information	8/67 (11.9)
	Staff seasonal influenza vaccination information	10/71 (14.1)
	Volunteer seasonal influenza vaccination information	4/65 (6.2)

Table 2.7. Overall level of infectious disease responses by annual animal intake, annual budget, number of full time employees from 78 animal shelters in Colorado, Wyoming, Utah, Montana, North Dakota and South Dakota		
Variable (p-value)	Category	Kruskall-Wallis Mean rank
Annual animal intake (<0.000)		
	7 - 150	21.33a
	151-388	24.28a
	389-780	29.08a
	781-2519	38.34a
	2520-8000	57.75b
	8001-28,000	52.67ab
Annual budget (<0.000)		
	500-8,000	14.69a
	8,001-24,500	29.39a
	24,501-122,500	26.12ab
	122,501-410,000	36.06ab
	410,001-1,200,000	48.55b
	1,200,001-10,000,000	58.92b
Number of full time staff (<0.000)		
	0-1	27.96a
	2-3	32.21a
	4-7	43.69ab
	8-120	55.43b
Shelter admission type (<0.01)		
	Limited admission	37.85a
	No-kill	26.68a
	Sanctuary	30.25a
	Rescue	17.0ab
	Other	27.62ab
	Open admission	47.35ab

[i] Access, Microsoft Corp, Seattle, Washington
[ii] SPSS, Inc., Chicago, Illinois
[iii] STATACORP, College Station, Texas

Chapter 3: Environmental sampling for *salmonella spp.* in Colorado animal shelters

Introduction

Salmonella is an important and emerging zoonotic pathogen worldwide. [1,2] Human infections with salmonella occur through food-borne transmission and also on occasion through contact with companion animals. [3,4] Companion animals in animal shelters may serve as a source of human infection. Companion animals may be exposed to *salmonella* spp. through a number of sources prior to arrival at a shelter. Roaming and contact with carrion, eating of wildlife species, exposure through contact with livestock or raw food diets have been sources of exposure of companion animals to salmonella. [5,6] Estimates of *salmonella* spp. prevalence in companion animals vary tremendously. Isolation rates from asymptomatic cats ranges from 0-14% and in asymptomatic dogs from 0-43%. [5] Recent studies put estimates at 1.2% [7], 2.1 [8] and 2.3% [9]. However, prevalence of *salmonella spp.* in stray or shelter dogs has been shown to be higher than in client-owned household dogs: 6.3% vs. 2.1% [8] and 15.8% vs. 4.4% [10].

Bacterial contamination of animal environments can occur when a pathogen is spread throughout a facility by animal or human traffic. Nosocomial outbreaks of *Salmonella* have occurred in small and large animal facilities. [11-14] Environmental surface sampling can be used to detect contamination of animal environments with pathogens or particles that have the potential to be transmitted to animals or

humans. Electrostatic wipes have been used for environmental surface sampling and for environmental surveillance in animal facilities. [15]

The level of *salmonella* in shelter animals and shelter environments is unknown. The objectives of this study were to estimate the prevalence of environmental *salmonella spp.* in animal shelters in Colorado, describe shelter policy and infection control practices, and identify risk factors for environmental *salmonella spp.* contamination. The hypothesis is that the prevalence of *salmonella* will vary by location and species within the shelters; prevalence will also vary between shelters based on shelter size, shelter type and geographical location.

Methods

Target population and sampling frame - One hundred and fifty-seven animal shelters in Colorado, Wyoming, Montana, Utah, North Dakota and South Dakota were identified in an animal shelter needs assessment survey study completed in 2006. (Steneroden, Chapter 2) All 60 shelters identified in the state of Colorado were included in the sampling frame for environmental sampling for *salmonella* spp., and were sent letters requesting participation followed up by a phone call explaining the project. All samples were collected during the months of July, August, September and early October of 2008 or 2009 as studies have been shown these to be months with highest prevalence of *salmonella* spp.[16] A sample submission form with demographic and infection control practice data was completed by the investigator for each participating shelter including shelter type, animals accepted, presence of a veterinarian on staff, disinfectant use, diagnostic testing for diarrhea, percentage of animals that have or develop diarrhea at the shelter, presence or

absence of an infection control manual, and written protocol for general cleaning and disinfection. When laboratory results were obtained, animal shelters were informed of their environmental sampling results.

Sampling locations - The following locations within an animal shelter were sampled if present: animal intake areas, animal exam areas, pediatric and adult animal wards, animal transport vehicles, public access areas such as lobbies and worker areas such as break rooms and/or restrooms. These locations were chosen because they varied in the presumed presence or absence of housed animals, the medical status and knowledge of the behavior of the animal, and/or the amount of physical contact the shelter animals might have with staff and/or with the public.

Locations within the shelters were further categorized based on the species housed or seen in those areas and included 8 categories, if present: canine, feline, mixed companion (which includes only canine and feline), human, wildlife, reptile, large animal (equine, small ruminant) and mixed companion animal (which includes canine, feline, avian, small mammal, reptile).

Sample collection - Environmental samples were collected by electrostatic wipe from select locations throughout the animal shelters using Swiffer Sweepers® and cloths [a]. "Floor" samples were taken from floor areas using the electrostatic wipe attached to the sweeper. "Hand" samples were those taken with an electrostatic wipe using a gloved hand from surfaces with human hand contact, including countertops, door knobs, telephones, equipment, cages, food dishes, and computer keyboards. Wipes were immediately placed into pre-labeled sterile bags [b]. The sweeper was disinfected with 70% ethanol between uses and allowed to dry.

Samples were transported to the laboratory and processed within 48 hours of collection.

Sample processing – Buffered peptone water [c] (90mls) was added to the bags containing the electrostatic wipes and incubated for 24 hours at 37°C. Enriched samples (1ml) were passed to tetrathionate broth containing iodine [d] (9ml) and incubated for 24 hours at 42°C. Samples were vortexed and passed to Rappaport-Vassiliadis R10 broth [e] (0.1ml to 10ml). After incubating 24 hours at 37°C tubes were vortexed and streaked for isolation on xylose-lysine-tergitrol (XLT-4) [f] agar plates and incubated for 24 hours at 37°C. Colonies typical for *Salmonella* spp (discrete, round, red colonies with a black center after 24 hours of incubation at 37°C) were selected and inoculated in triple sugar iron agar (TSA) [g] and urea agar slants [h] and incubated at 37°C for 24 hours for biochemical confirmation. Because sample processing involves an enrichment process qualitative results of the presence or absence of *salmonella* was reported.

Phenotype characterization – Biochemically confirmed *Salmonella* spp isolates were serogrouped by use of commercial polyvalent O antisera (groups A through I and Vi) [i] and individual O grouping antisera. Samples that did not agglutinate were further characterized by use of a commercial identification system.[j] Colonies with positive results for agglutination with polyvalent antisera or identified as *Salmonella* spp by the commercial system were serotyped by the National Veterinary Services Laboratory (NVSL), Ames, Iowa. Isolates were evaluated by characterizing antimicrobial susceptibility to a standardized panel of antimicrobial drugs (amikacin, amoxicillin-clavulanate, ampicillin, ceftiofur,

cephalothin, chloramphenicol, enrofloxacin, gentamicin, streptomycin, sulfamethoxazole) by use of the Kirby-Bauer disk diffusion method. Assays were read on a commercial reading system. [k] Assays and interpretations were conducted in compliance with the standard procedures. [17]

Statistical analysis – Laboratory results and survey observational data were entered into a database [l] analyzed for associations using a statistical software package [m]. Random effects logistic regression modeling was used to account for clustering at the shelter level and to test for significance of variables. Positive sample was the outcome, shelter the random effect and all other variables explored as fixed effects. The level of statistical significance was < 0.05.

Results

Demographic information and environmental samples were collected from 32 animal shelters. Open admission shelters comprise the majority of shelters surveyed and sampled with median annual animal take of 625 animals and a median number of animals on site of 57. (Table 1) The majority of animal shelters accepted canines and felines; roughly half accept avian, reptiles, amphibians, small mammals, pigs, and small ruminants and about a third of shelters accept horses and wildlife species (Table 1) The majority of shelters did not have a veterinarian on staff. (Table 1) Infection control practices used included the presence of written protocols for cleaning and disinfection (68.8% of shelters) and presence of an infection control manual (9.4% of shelters) (Table 1)

Of the 428 environmental samples collected, 30 individual samples and 9 animal shelters were positive for environmental contamination with *salmonella.* (Table 2) Six serogroups were identified. (Table 2)

Positive shelters were often positive in more than one location within the shelter. On average, 22% of locations within a positive shelter were positive with a range of 4-100% of locations being positive for environmental contamination with *salmonella.* (Table 2) Five out of nine shelters sampled had contamination with more than 1 serogroup of *salmonella.* (Table 4) A high percentage 24/29 (82.8%) of *salmonella* isolates exhibited resistance to one or more antimicrobial agents with 23/29 (79.3%) resistant to sulfamethoxazole and 33.0% of isolates resistant to 6 or more antimicrobial drugs.

The sampling location within shelters, shelter type and shelter size were not associated with salmonella contamination; however predominant species within a location was significant with canines being most associated with a positive location. (Table 3) There was also a statistically significant association between geographical location within Colorado and a shelter having environmental contamination with *salmonella.* (Table 3) Intracluster correlation coefficient (ICC) was determined through large sample ANOVA to be 0.3217 for this dataset. Likelihood ratio testing determined the random effects logistic regression model which included shelter as the random effect, sample positive as the outcome, and geographical location and species as fixed effects to be a better fit than logistic regression. (LR=5.22)

Discussion

Results of this study indicate that animal shelters can be frequently contaminated with *salmonella* spp., a variety of *salmonella* species may be present in an animal shelter facility and contamination can be widespread within a facility.

Geographical location within Colorado was a significant risk factor for *salmonella* with the majority of positive shelters being in the eastern 1/3 of the state. All animal shelters sampled in the Eastern plains (3/3) and approximately one third of the shelters on the Front Range (5/18) were positive for environmental contamination with *salmonella.* Thought not examined specifically, a reasonable explanation may be human and bovine population levels/distributions in the state. Over 85% of Colorado's 4.9 million human inhabitants [18] and over 80% of its 2.7 million cows [19] resides on the Eastern Plaines and Front Range of the state. The increased prevalence of *salmonella* in animal shelters may be due to the increased human population in the region, presence and proximity of livestock facilities such as beef feed lots or dairy operations or could also be related to or affected by environmental factors such as elevation, rainfall or temperature.

The environmental contamination found in this study could be from animals clinically ill with salmonellosis, but it is also likely that contamination is from non-clinically ill animals as most cases of canine salmonellosis are asymptomatic [5,20]. No shelters in this study tested for or diagnosed salmonella in a shelter animal, so whether animals were symptomatic or asymptomatically shedding salmonella is unknown. Predisposing factors that may precipitate shedding and/or clinical salmonellosis in previously asymptomatic carrier animals include stress, heavy parasite burden, antimicrobial therapy, surgery, anesthesia, concurrent infection,

malnutrition, and water deprivation [5]. Stress is present in all shelter environments and the other predisposing factors may also be present, and precipitating shedding of *salmonella spp.*. *Salmonella* should be a differential diagnosis for animal shelters when dealing with diarrheic animals and diagnostic testing considered when other common conditions such as parvovirus or panleukopenia are ruled out.

The variety of *salmonella* species present in each facility may be due to shedding by multiple animals, but may also be due to the shedding of multiple *salmonella* species by a single shedding animal. It is not uncommon for a single animal to shed multiple species of *salmonella* [5,6,21] Length of time that an animal sheds *salmonella*, and thus in part its ability to cause widespread environmental contamination, is highly variable. Asymptomatic carrier animals tend to shed intermittently for relatively short periods [5] while clinically ill animals who typically shed larger numbers of *salmonella* [5] may shed for prolonged periods of time – up to 12 weeks in the case of a cat with MDR *salmonella* Typhimurium Dt104. [22]

The high prevalence of antimicrobial resistance in this study indicates that susceptibility testing may be useful and influence chemotherapeutic choices in animal shelters. Animal shelter antimicrobial drug use practices may be contributing to the level of antimicrobial drug resistance seen in this study.

On univariable analysis reptiles were significantly associated with a positive shelter. However, when added to the regression model reptile was not significant most likely due to the small number of reptile only locations. Given the high prevalence of reptiles that are asymptomatic carriers of *salmonella* [23] reptiles should be considered a high risk species for salmonella shedding in animal shelters.

Reptiles (as well as wildlife, livestock and avian species) are often transient residents at animal shelters. In this study, 53% of shelters accepted reptiles, but most housed them only temporarily and transferred them to rescue organizations that are better able to handle their unique husbandry needs. Some shelters kept reptiles and housed them with other species. Three animal shelters in this study had specific rooms to house reptiles and saw a high volume of reptiles. Two of the three shelters with specific reptile rooms tested positive for environmental contamination with *salmonella*. One of these shelters was re-visited after thorough cleaning and disinfection. Upon re-sampling for environmental contamination, the reptile room was again positive for *salmonella*, but this time with a different serogroup of *salmonella* (data not shown). Although the number of animal shelters tested was low, and the number with specific reptile rooms even lower, this repeated contamination with *salmonella* indicates that the risk from *salmonella* from reptiles is important and on-going. Workers, volunteers and the adopting public should be made aware of the potential for *salmonella* in shelter reptiles and for their safe handling.

Animal shelters may choose to keep and house reptiles with other species but wildlife, as unadoptable species, are usually only housed in their own separate areas. Twelve shelters accepted wildlife species but only 3 shelters housed them long term. Wildlife species have been implicated as a source for *salmonella* for humans and domestic animals [24] [25] but were a low risk species in this study. This may be due to the limited number of shelters in this study that house wildlife on a long term basis.

Two salmonella positive shelters, numbers 4 and 5 (Table 5) are located within 20 miles of each other Although they are separate animal shelters administratively, they share volunteer personnel and transfer animals between the two shelters. Similar salmonella isolates with similar antimicrobial resistance patterns were isolated from these shelters supporting nosocomial transmission between the shelters.

Salmonella can be a risk for companion animal owners and families including those who adopt from animal shelters due to close contact with animals in the home. [26] To individuals with compromised immune systems, including children, the elderly, pregnant women and those using immunosuppressive drugs, *salmonella* is a pathogenic risk. [26,27] *Salmonella* can also be a risk through environmental contamination as household contamination with *salmonella* has occurred in homes with occupational exposure to *salmonella.* [28] Control of environmental contamination is an important infection control concern especially in the control of nosocomial infection in human and animal facilities. [29] Further investigation with animal fecal samples in conjunction with environmental samples to further characterize animal shedding and environmental contamination in animal shelters, its transmission to other animals and to humans is necessary.

As with any study there were important limitations to the present findings. Not all shelters in Colorado were sampled and this study represents a convenience sample of shelters willing to participate, potentially resulting in selection bias. Shelters that agreed to be sampled may have a different set of infection control practices than those that did not. If infection control practices in sampled shelters

were better than those in shelters not sampled, this study would under estimate environmental contamination with *salmonella*. If infection control practices in sampled shelters were worse than the infection control practices in those shelters not sampled, this study would over estimate environmental contamination with *salmonella*.

The source of the environmental contamination in animal shelters with *salmonella* is not known. Fecal samples from animals were not collected and tested in this study. Because *salmonella* can be spread on the shoes of workers or visitors, the *salmonella* found in shelters could have been from the animals or tracked in from humans. However, if humans were the source of environmental contamination in the shelters, more human predominant areas would likely have been positive.

Shelters facilities and floor plans are all very different and locations within the shelters difficult to compare. This may have been a reason for the lack of association between location within a shelter and salmonella contamination. Every effort was made to correctly categorize room locations and species locations, but the fluidity of animal and human movement within animal shelters makes this difficult.

No one sampling method can completely characterize bacterial contamination on surfaces. [30] Surface sampling encompasses many different techniques and methods depending on the policies and requirements who is doing the sampling, the type and extent of the surface being sampled, the expected organism, laboratory capability and capacity, the need to quantify results and the degree of health risk to animals and/or to humans. [31] Peer reviewed papers have published on the use of electrostatic wipes in veterinary teaching hospitals for

salmonella surveillance [15] and in homes looking for endotoxin [32]. To the authors knowledge there are no studies which validate electrostatic wipe method or compare it to any other qualitative surface sampling methods. Several factors affect the ability of the electrostatic method to collect salmonella on an environmental surface as well as the ability of the laboratory analysis to detect salmonella in a sample. These include climate, surface type, pathogen persistence in the environmental, bacterial load, technical knowledge of the laboratory staff. Samples determined to be positive for salmonella were confirmed by additional testing at the NVSL to be salmonella. Samples determined to be negative for salmonella may have been mis-reported due to imperfect sensitivity of our sampling method and laboratory analysis. As a result salmonella prevalence in animal shelters may be underestimated in this study.

Because the study was carried out in a limited geographical area in the United States, care should be taken when extrapolating the results to other areas.

The human and veterinary medical communities are both interested in zoonotic diseases, emerging zoonotic diseases and zoonotic disease awareness. Animal shelter animals and workers are a potentially vulnerable population whose exposure to zoonotic diseases such as *salmonella* may be greater than the general population. This study is part of a larger project which has the goal of learning more about infection control and zoonotic disease awareness practices in animal shelters along with evaluation of mitigation efforts. Determining the level of a zoonotic disease in shelter animals is the first step in analyzing risk to shelter animals, animal shelter workers and the adopting public. The results of this study may influence and

help focus education policy on issues of infection control and zoonotic disease awareness in animal shelters.

a. Swiffer, Proctor & Gamble, Cincinnati, Ohio.
b. Whirl-pak, NASCO, Modesto, Calif.
c. Buffered peptone water, Becton Dickinson and Co, Cockeysville, Md
d. Tetrathionate, Becton Dickinson and Co, Sparks, Md
e. Rappaport, Remel, Lenexa, Kan.
f. XLT-4, Hardy Diagnostics, Santa Maria, Calif.
g. Triple sugar iron agar, Becton Dickinson and Co. Sparks, Md
h. Urea agar slants, Becton Dickinson and Co. Sparks, MD
i. Grouping antisera, Becton Dickinson and Co, Sparks, Md
j. Micro-ID, Remel, Lenexa, Kan
k. Biomic, Giles Scientific Inc. Santa Barbara, Calif.
l. Access, Microsoft Inc., Seattle, Wa
m. SPSS, SPSS, Inc. Chicago, Illinois

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Tables

Table 3.1. Demographic and infection control information from 32 animal shelters in Colorado.			
Variable	**Category**	**Number (percent)**	**95% CI**
Shelter type			
	Open admission	16/32 (50.0)	31.9-68.1
	Limited admission/low kill	12/32 (37.5)	21.1-56.3
	Sanctuary/rescue	4/32 (13.5)	3.4-29.0
Shelter size			
	Annual intake: mean 625 (range 12 – 23,500)		
	Animals present at any one time: mean 57 (range 8-400)		
Animal type accepted			
	Canine	26/32 (81.2)	63.6-92.8
	Feline	29/32 (90.6)	75.0-98.0
	Bird	20/32 (62.5)	43.7-78.9
	Reptile	17/32 (53.1)	34.7-70.9
	Amphibian	13/32 (40.6)	23.7-59.4
	Small mammal	20/32 (62.5)	43.7-78.9
	Pig	14/32 (43.8)	26.4-62.3
	Small ruminant	16/32 (50.0)	31.9-68.1
	horse	11/32 (34.4)	18.6-53.2
	Wildlife	12/32 (37.5)	21.1-56.3
	other	3/32 (9.4)	2.0-25.0
Veterinarian on staff			
	Full time	6/32 (18.8)	7.21-36.4
	Part time	8/32 (25.0)	11.5-43.4
	Other: Relief, consulting, no vet	18/32 (56.2)	37.6-73.6
Infection control practices			
	Written protocol for cleaning and disinfection	22/32 (68.8)	50.0-83.9
	Cleaning and disinfection training offered to workers	19/32 (59.4)	40.7-76.3
	Written shelter infection control manual	3/32 (9.4)	2.0-25.0
	Advised workers and volunteers of zoonotic risks	20/32 (62.5)	43.7-78.9

Table 3.1 continued			
In-shelter diagnostic testing done for diarrhea			
	Snap parvo	17/32 (53.1)	34.7-70.9
	Fecal float	18/32 (56.0)	37.6-73.6
	Fecal smear	12/32 (37.5)	21.1-56.3
	Sent out	18/32 (56.2)	37.6-73.6
	Giardia	9/32 (28.1)	13.8-46.8
	Salmonella	0/32 (0)	0-10.9
	% of dogs that develop diarrhea while a shelter resident	5%	
	% cats that develop diarrhea while a shelter resident	10%	

Table 3.2. Characterization of *Salmonella spp* positive samples (n= 30) from 32 animal shelters in Colorado.			
	Group	**Number (percent)**	**95% Confidence interval**
Shelters positive for *salmonella*		9/32 (28.1)	13.8-46.8
Samples positive for *salmonella*		30/428 (7)	4.8-9.9
***Salmonella* groups identified**			
	C2	14/30 (46.6)	28.3-65.7
	No group	8/30 (26.6)	12.3-45.9
	B	4/30 (13.3)	3.8-30.7
	E	4/30 (13.3)	3.8-30.7
	C1	1/30 (3.3)	0.08-17.2
	D	1/30 (3.3)	0.08-17.2
Contamination in positive shelters		22% (Range = 4-100% of positive locations within positive shelters)	

Table 3.3. Characterization of *Salmonella spp.* positive animal shelters by sampling location, predominant species in location and geographical location.		
Sampling location (p=0.15)		
	Location	**Number (percent)**
	Outside play areas	2/12 (16.6)
	isolation	5/45 (11.1)
	Wards/kennels/cages	11/131 (8.4)
	Mixed location	1/14 (7.1)
	Human location	6/116 (5.2)
	Holding	1/33 (3.0)
	Surgery room	0/1 (0)
	Transport vehicles	0/19 (0)
Predominant species in location (p=0.02)		
	Reptile	2/3 (66.6)
	Canine	11/85 (12.9)
	Mixed companion (canine, feline, small mammal, reptile, avian)	7/63 (11.1)
	Human	6/121 (5.0)
	Mixed-canine/feline	1/24 (4.2)
	Large animal	1/23 (4.3)
	Feline	4/105 (3.8)
	Wildlife	0/3 (0)
Geographical location (p=0.01)		
	Eastern plains	3/3 (100.0)
	Front range	5/18 (27.8)
	Mountain region/Western Slope	1/13 (7.7)

Table 3.4: Positive locations, species, serogroup, serotype and antimicrobial resistance pattern of *Salmonella spp.* isolates in 9 Colorado animal shelters.

Shelter	Positive locations	Species category	Sero-group	Serotype	Amik	Amox	Amp	Cef	Ceph	Chlor	Enro	Gent	Strep	Sulf	Tetra	TMS
1	Office/restroom	4	NG*	*NT	S	S	S	S	S	S	S	S	I	R	R	R
2	Isolation	2	E	Senftenberg	S	R	R	S	I	R	S	R	R	R	R	S
	Ward	6	NG*	41;z4,z23:-	S	S	S	S	S	S	S	S	S	S	S	S
3	Exam-hands	8	B	4,12:1:-	S	S	S	S	S	S	S	S	S	S	S	S
	Visitation	8	D	Panama	S	S	S	S	S	S	S	S	S	S	S	S
	ward	6	NG*	Kokomlemle	S	S	S	S	S	S	S	S	S	R	S	S
	ward	8	NG*	NT*	S	S	S	S	S	S	S	S	S	R	S	S
	Pharmacy/iso/exam/.treatment	8	NG*	Kokomlemle	S	S	S	S	S	S	S	S	S	R	S	S
4	Kennel	1	C2	*NT	S	S	I	S	I	S	S	S	S	R	I	S
	Feed room	3	C2	*NT	S	S	I	S	I	S	S	S	S	R	I	S
	Entry/euthanasia	3	C2	Newport	S	S	I	S	I	S	S	S	S	R	I	S
5	Euthanasia	3	C2	Newport	S	S	S	R	S	S	S	S	S	R	I	S
	Receiving-hands	3	C2	Newport	S	S	S	I	S	S	S	S	I	R	I	S
	kennel	1	C2	Newport	S	S	S	S	S	S	S	S	I	R	I	S
	Office-hands	4	C2	Norwich	S	S	S	S	S	S	S	S	S	R	I	S
	Office-floor	4	C2	Newport	S	S	S	S	S	S	S	S	S	R	I	S
	Isolation	3	C2	Newport	S	S	S	S	S	S	S	S	I	R	I	S
	Outside area	1	C2	Newport	S	S	S	I	S	S	S	S	I	R	I	S
6	kennel	2	B	4,12:1-	S	S	S	S	S	S	S	S	R	R	S	R
	Office/break area	4	C1	Norwich	S	S	S	S	S	S	S	S	S	R	S	S
7	ward	2	NG*	Senftenberg	S	S	R	S	S	R	S	R	R	R	R	I
	kennel	1	E	Senftenberg	S	I	R	S	I	R	S	R	R	R	R	R
	Pediatric ward	1	NG*	Senftenberg	S	I	R	S	I	R	S	R	R	R	R	R
	isolation	1	NG*	Senftenberg	S	I	R	S	R	R	S	R	R	R	R	S
	receiving	1	E	Senftenberg	S	I	R	S	I	R	S	R	R	R	R	R
	euthanasia	8	E	Senftenberg	S	I	R	S	I	R	S	R	R	R	R	S
8	ward	7	C2	Not done												
9	isolation	2	B	Typhimurium	S	S	S	S	S	S	S	S	S	S	S	S
	Isolation	1	C2	Cerro	S	S	S	S	S	S	S	S	S	S	R	S
	Ward	1	C2	Kentucky	S	S	S	S	S	S	S	S	S	S	S	S

Species categories: 1=canine, 2=feline, 3=mixed (canine and feline), 4=human, 5=wildlife, 6=reptile, 7=large animal, 8=mixed companion (canine, feline, reptile, avian, small mammal, large animal, wildlife).
S=sensitive, I=intermediate sensitivity, R=Resistant
*NG=no group
*NT=not typeable
Amik-amikacin, Amox=amoxicillin-clavulanic acid, Amp=ampicillin, cef=ceftiofur, Ceph=Cephalothin, Chlor=chloramphenicol, Enro=enrofloxacin, Gent=gentamicin, strep=streptomycin, sulfa=Sulfomethoxazole, tetra=tetracycline, TMS=trimethoprim-sulfamethoxazole.

Chapter 4: Infection Control for Animal Shelters

This chapter contains 2 sections: Introduction to Infection control for Animal Shelters and Principles of Infection control for Animal Shelters written for the Maddie's Infection Control Manual for Animal Shelters, 2008, Published by the Center for Food Security and Public Health, Iowa State University, College of Veterinary medicine, Ames, Iowa 50011 USA. Both of the sections were co-authored with Christine A. Peterson, Glenda Dvorak and Anna Rovid Spickler. The infection control manual was developed as a resource for veterinarians and veterinary students involved in animal shelter medicine. The purpose of the handbook is to enhance knowledge about infection control measures in the shelter environment, and to aid veterinary professionals in the development and implementation of infection control protocols.

Introduction to infection control for animal shelters

Animal shelters provide temporary or permanent homes for animals and resources for people looking for animal companions. Each year, six to eight million animals enter nearly 6,000 animal shelters. While shelters vary in setup and organization, one thing they all have in common is a high risk for infectious diseases. While the risk for these diseases cannot be completely eliminated, steps can be taken to minimize their introduction and spread. These measures protect not only the animal population within the shelter, but also the people working with and/or adopting the animals. This chapter addresses the importance of infection control in animal shelters, while confronting the challenges and unique risk factors inherent in

this setting. It also discusses the routes of disease transmission and explains how to use this information to control a wide variety of infectious diseases simultaneously.

It should be remembered that many pathogens may be primarily transmitted by one or a few routes, but this does not mean that other routes of transmission are not possible means of disease spread. Due to this possibility, precautions must be taken to guard against transmission of a disease through any possible route of transmission. Many of the infection control measures specified in this manual, for instance, vaccination and diagnostic testing specified to prevent reproductive transmission are equally valid control measures for other routes of transmission as well.

The Importance of Infection Control in an Animal Shelter

The millions of animals and people who enter animal shelters each day may be exposed to a number of infectious diseases. The animals that become infected may be euthanized due to illness or to control the spread of disease. Humans who become infected may suffer serious consequences including fatal rabies or the birth of a damaged child, as well as less severe but nonetheless debilitating illnesses such as diarrhea. An effective infection control plan can prevent some of these consequences. In addition, it could provide a measure of security against new or emerging pathogens, such as the canine influenza virus, which might otherwise enter shelters unchecked.

In the past, animal health programs and infection control measures were either very basic or non-existent in animal shelters. Out of necessity, euthanasia was the primary population control method. A lack of information on the disease status

of the animals in shelters, as well as the number of admissions, adoptions and euthanasia, prevented a clear understanding of animal health and well-being. Today, animal shelters seek to reduce the number of animals euthanized, in part by increasing the number of adoptions. To do this, better disease prevention, improved infection control strategies, enhanced animal health management, and more detailed record-keeping have become critical.

Challenges of Infection Control in Animal Shelters

The challenges of controlling infectious disease in an animal shelter are enormous. These animal populations change constantly, with the daily addition of new animals whose medical and behavioral backgrounds are largely unknown. Overcrowding, a perpetual problem in shelters, facilitates the transmission of disease. Several factors can contribute to overcrowding. In many shelters, the intake of animals cannot be limited or controlled. In addition, mandatory animal holding periods must be followed in all shelters. In no-kill or low-kill shelters, animals may be housed for months or years before adoption; this can cause further crowding unless admissions can be limited. Human traffic in the form of staff and volunteers, potential adopters, and owners looking for lost pets adds to the difficulty in controlling the spread of infectious diseases. Funding is almost always limited, so budgets for animal health and preventative medicine are a constant concern. In some shelters, there may be no clear "mission or vision statement" to direct animal health decisions. Shelter managers may have little expertise in animal health, and/or lack the time or staff to better organize shelter policies. Shelter work is stressful and maintaining trained personnel is difficult; there often is high turnover

of staff and volunteers, and this staff may not be trained adequately. Burnout is also common, particularly among staff members involved in euthanasia.

Infection control can also be hampered by a lack of expert advice. At some shelters, veterinary input may be ignored, limited, or non-existent. However, as public awareness of shelter issues has improved and shelter budgets for veterinary care have increased, this situation is changing. Many shelters now employ veterinarians on either a full or part time basis, or have veterinarians who provide on-call services. Veterinarians can provide valuable advice on a wide variety of shelter issues, including animal health and disease control measures such as infection control plans. In addition, veterinarians may be consulted on shelter design, population medicine, animal behavior assessment, staff training, humane education, behavioral enrichment, foster care, feral cat management, euthanasia programs and media events.

What is an Infection Control Plan?

Infection control is important in routine disease prevention, as well as in controlling outbreaks. An infection control plan consists of the measures taken to prevent the introduction of contagious diseases into a facility, as well as the procedures used to control their spread. Essential infection control measures in an animal shelter include maintenance of animal health, appropriate vaccination practices, effective cleaning and disinfection protocols, good facility design and management, functional shelter policies and procedures (e.g., staff movement, animal movement, isolation protocols), and education of the shelter staff and volunteers on these practices. In addition to protecting the animals from infectious

diseases, these measures also protect the shelter staff, volunteers and potential adopters from zoonotic infections. Some infection control measures are simple to implement; others require time, training, and/or additional finances. Each facility is different and will require an individualized plan. Developing infection control measures requires a comprehensive understanding of the risk factors for infectious diseases.

Infectious Disease Risk Factors in Animal Shelters

Any facility handling animals faces problems with disease, but several factors make infections particularly difficult to control in animal shelters. These factors include overcrowding, stress and other factors that decrease immunity, and high turnover rates in both animals and people.

Overcrowding. Holding large numbers of animals in a confined space increases an animal's risk of exposure to disease agents. Pathogens spread readily in this situation, where animals may be exposed frequently to each other's secretions (e.g. saliva) and excretions (e.g. feces). Aerosol transmission also becomes more efficient when animals breathe the same air. In addition, the pathogen load can be high in shelters, particularly during outbreaks.

Stress and other factors contributing to decreased immunity. Stress can suppress the immune system, limiting an animal's ability to fight off infection or disease. Latent (dormant) infections can also be reactivated when the immune system is suppressed. Some latent infections may become symptomatic; in other cases, the reactivated organisms replicate subclinically, and the pathogen is shed from an apparently healthy animal. Shelter environments are usually stressful: they

are unfamiliar to the animals and are often noisy. They are also frequently overcrowded, further increasing stress levels.

Other factors also increase the shelter population's vulnerability to disease. Shelters often house unvaccinated or under-vaccinated animals, which are susceptible to serious viral diseases such as distemper, parvovirus, or panleukopenia. Young animals are also common in shelters. Kittens and puppies cannot mount a good immune response to a vaccine until their maternal antibodies have diminished, which occurs at a different time in each individual. The usual kitten/puppy vaccination protocol provides an adequate safety net for animals in private homes; however, a young animal in a shelter might be exposed to the pathogen before it receives its next vaccination or before the vaccine can take. In addition, the underdeveloped immune system of a young animal may not mount an immune response as quickly as a healthy young adult. Geriatric animals may also have weaker immune systems due to age or a chronic condition.

Turnover and exposure. The turnover rate for both animals and people in shelters can be very high. New animals constantly enter the animal shelter, bringing pathogens with them, and other animals may leave the shelter with diseases they have picked up in this environment. The latter animals, while not a direct risk to the shelter, can expose other pets and people in the community. Daily staff and volunteers can also have a high level of turn-over. In addition, staff or volunteers interact with multiple animals, which can spread disease. These factors contribute to continual changes in the mixture of pathogens present at the shelter, and a

constant source of susceptible animals and people. Once this situation has been established, it can be very difficult to break the disease transmission cycle.

Characteristics of Pathogens in Animal Shelters

While infectious diseases vary in many ways, they share one trait: the animal must be exposed to the pathogen to develop the disease. An infection control strategy can stop illness by interrupting the transmission of microorganisms between animals. Before an infection control protocol can be developed, the characteristics of the relevant pathogens must be assessed; these characteristics include each pathogen's route of transmission, as well as its persistence in the environment, infectious dose, and incubation period, and the potential for a latent or carrier state in the affected host(s).

Routes of Transmission for Diseases

Understanding how pathogens enter or spread within an animal shelter is important in developing an infection control plan. While disease-specific measures can be useful, interrupting the various routes of transmission prevents spread of many different diseases by interrupting the means by which they are spread. It also helps to protect animals from new or unexpected pathogens as well as common diseases. For example, diseases such as kennel cough, canine influenza, and feline upper respiratory infections can all be transmitted via aerosols. Measures including the isolation of contagious animals, ventilation designs that prevent airflow from sick to healthy animals, and effective cleaning and disinfection procedures can help control the introduction and spread of all of these diseases at once.

Since animals may be infected with a disease without exhibiting obvious symptoms, they can introduce diseases into the animal shelter unless staff is aware of this possibility and maintain good infection control precautions at all times. Animal caretakers should be trained to understand the various routes of disease transmission and how to prevent disease spread. Pathogenic agents can be spread between animals and/or to humans by five primary routes of transmission: via direct coat to coat contact, in aerosols, by the oral route (ingestion), and indirectly on fomites or a sub-group of fomites; insect vectors. Multiple routes of transmission are possible for many pathogens.

Airborne. Airborne transmission occurs when pathogenic agents contained in aerosolized droplets are passed from one animal to another or from an animal to a human. Many pathogens do not survive for extended periods within aerosol droplets; close proximity of infected and susceptible animals is often needed for aerosol droplet transmission. *Bordetella bronchiseptica* infection (kennel cough) and feline upper respiratory disease caused by feline caliciviruses and feline herpesvirus are examples of diseases transmitted in aerosols. Possible control measures include altering the cage/kennel layout to increase the distance between animals, isolating animals with signs of respiratory disease, and ensuring there is adequate/appropriate ventilation and air filtration.

Oral/Ingestion. Oral transmission involves the consumption of pathogenic agents. These organisms may be ingested in contaminated food and water, or they may be acquired while licking or chewing contaminated objects. Food and water become contaminated when they are exposed to disease agents in feces, urine, or

other body secretions and excretions. Animate fomites such as rodents can also transfer pathogens to food. Other contaminated objects could include equipment, food and water bowls, cages, and any other item an animal may lick or chew. Feline panleukopenia and canine parvovirus are often transmitted orally. Possible control measures include providing proper nutrition that is not contaminated, cleaning and disinfecting bowls and equipment frequently, and controlling insect vectors and vermin. To prevent human oral infection staff should always wash their hands prior to eating and staff members should not eat or drink in animal holding areas where pathogens may be present.

Direct contact. Direct contact is the transfer of a pathogenic organism from an infected animal to a susceptible animal without an intermediary. Exposure occurs when a pathogen in body secretions or excretions contacts mucous membranes or the skin during activities such as nose to nose contact, rubbing, licking, or biting. Some pathogens can infect hair follicles or other components of unbroken skin; however, most can enter the body only through mucous membranes or where the skin has been damaged. Ringworm is an example of a common shelter pathogen transmitted by direct contact. Possible control measures include preventing animal to animal contact, good hygiene practices, and the use of personal protective equipment (PPE) by staff.

Reproductive transmission, a subtype of direct contact, is the transmission of pathogens from animal to animal through coitus, or from mother to offspring (vertical transmission) during gestation or while nursing. These diseases can be

partially controlled by animal health measures such as vaccination of the dam, veterinary examinations and diagnostic testing for infectious diseases.

Fomite. Inanimate or animate objects can carry some pathogens from one animal to another. Bowls, buckets, carriers or cages, litter boxes, toys, blankets, any type of equipment (including grooming or treatment supplies), and hands are objects that can be contaminated with infectious agents. Clothing, footwear, or vehicles may also serve as fomites. After animals are exposed to the fomite, the pathogen generally enters the host by ingestion, through broken skin, or by contact with mucous membranes. Many pathogens found in shelters can be spread by fomites; feline panleukopenia and canine parvovirus are examples of organisms that can survive on objects for particularly long periods. Transmission on fomites can be controlled by cleaning and disinfection, good hygiene, and the use of dedicated protective clothing, such as gloves, masks, and coveralls.

Vector-borne. Some diseases are transmitted from one animal to another by insect vectors such as mosquitoes, ticks, fleas, and flies. Insect vectors transfer pathogens either mechanically or biologically. Mechanical transmission involves the simple transfer of a pathogen without replication or further development in the vector. Flies often act as mechanical vectors. Biological transmission occurs when a pathogenic organism must undergo part of its life cycle (i.e. replication or further development) within the insect; the pathogen is then transmitted to a susceptible animal by the insect, most commonly by injection. Some of these pathogens can also be passed to subsequent insect generations, particularly in ticks. Fleas, ticks, and mosquitoes are common biological vectors. For example, tapeworms can be

transmitted via flea bites in shelters. Vector control measures include the use of topical and environmental insecticides and screened windows.

Environmental transmission. Many infectious disease agents can survive for extended periods of time in the environment, including the soil. They can be acquired from the environment by various routes including ingestion, skin contact, and under some conditions, airborne transmission. A good infection control program will minimize environmental contamination, as well as prevent transmission from this source. Control methods include proper cleaning and disinfection, exposure to UV light or sunlight, personal hygiene, and the use of personal protective equipment.

Zoonoses. Diseases that can be transmitted from animals to humans or vice-versa are called zoonoses or zoonotic diseases. Humans can be exposed to animal pathogens by contact with the animal's secretions (e.g. saliva) or excretions (e.g. feces), by contact with pathogens on fomites, and sometimes via aerosols or in insect bites. The risk of acquiring a zoonosis can be reduced by the effective use of personal protective equipment and by personal hygiene such as frequent hand washing. Human infections are also prevented by treating or controlling zoonotic diseases in animals.

Disease Specific Considerations. Other factors must be considered when developing infection control procedures. These include pathogens persistence in the environment, the infectious dose in healthy and immunosuppressed animals, the incubation periods, and their ability to be shed by asymptomatic animals.

Pathogen persistence in the environment. A pathogen's structural and biological (e.g., ability to form spores) properties determine its resistance to environmental challenges. Many successful pathogens have derived ways to persist in the environment. For example, *Bordetella bronchiseptica*, the agent that causes kennel cough, can live for weeks in the moist environments frequently found in animal shelters. Similarly, both feline panleukopenia and canine parvovirus can remain active for months in fecal material or on the coats of animals. In contrast, the herpesvirus that causes feline rhinotracheitis is readily inactivated by drying, and it is mainly transmitted from cat to cat. Understanding each pathogen's resistance to inactivation can aid the development of appropriate protocols for isolation, cleaning, and disinfection.

Dose effect. The relationship between the number of infectious organisms required to make an animal sick and the ability of the animal's immune system to respond is called the dose effect. The infectious dose, or number of organisms required to infect the animal, varies with the organism. When either the dose of organisms is high or the host is immunocompromised, disease is more likely to occur. Lowering the number of pathogens to which an animal is exposed can prevent disease. This can be accomplished by cleaning and disinfection, isolation of infected animals, and measures to minimize overcrowding. Improving the immune status of an animal by vaccination, good nutrition, or stress reduction can also tip the balance and help prevent disease.

Incubation period. The period of time between exposure to a pathogen and the development of clinical disease is the incubation period. Incubation periods vary

between infectious agents and are also influenced by the immune status of the host. Some pathogens are shed during the incubation period, before the animal shows signs of illness. This highlights the need to implement disease control measures whether or not any animals have symptoms of disease.

Disease carriers. Many diseases can have carrier states. Carrier animals are those that are infected, but are not showing clinical signs. Carrier animals may be incubating an infectious disease, recently recovered but still shedding infectious particles, or chronically infected. These animals may be infectious for other animals. Although some agents, particularly viruses, are carried in a latent (dormant) state, others do not become truly dormant and are shed either constantly or intermittently. Latent viruses can become reactivated when an animal becomes immunosuppressed. The feline herpesvirus, an important pathogen in animal shelters, is an example of a virus that has a latent stage. Feline herpesvirus infections often recur in stressed cats, including cats that enter a shelter.

Steps to Developing an Infection Control Program

Several basic steps should be followed in the development of an infection control plan. They include:

- Assessment of shelter-specific risk factors for the introduction of disease
- Development of shelter-specific infection control polices and procedures
- Training and education of shelter staff and volunteers regarding infection control principles and protocols
- Effective and consistent implementation of infection control policies and procedures

- Monitoring and assessment of the efficacy of the infection control program

Assessment of Risk Factors

The risk assessment evaluates the strengths and weaknesses of a specific shelter, in relation to the entry and spread of pathogens. The assessment should include the facility's design and management, both human and animal traffic flow within the shelter, and the knowledge and training of the personnel. All aspects of the current infection control procedures, including cleaning and disinfection protocols, isolation protocols, and policies on hygiene and personal protective equipment should also be evaluated.

Development of Policies and Procedures

Once the assessment of risk factors is complete, effective policies and procedures should be established. Some questions to consider when developing an infectious disease protocol for a shelter include:

- How will infectious disease be recognized?
- Will diagnostic testing be performed? Which tests, and by whom?
- Who will be notified when a specific disease is identified? When and how should the notification take place?
- What will the treatment and/or prevention measures be for the specific disease?
- How should the affected animal be housed (e.g., isolation)?
- How will exposed animals be housed and monitored?
- What are the appropriate disinfection measures?
- What will the adoption policy be for an affected animal?

- What documentation will be necessary?

Ideally these protocols would be established before a case of the disease or an outbreak occurs. The program should be initiated with those procedures that are inexpensive and relatively easy to implement, yet yield high rewards. Infection control policies and procedures should be written, and they should be maintained in easy-to-access location(s). This allows personnel the opportunity to refer to the policies as needed.

Training and Education

For the policies and procedures to be carried out effectively, shelter staff and volunteers must be trained well, and also educated as to the procedures' importance. Education helps to improve compliance. Training should be repeated frequently due to the high turnover of personnel in shelters. Ongoing training will also be necessary as policies change or are modified.

Implementation of Policies and Procedures

The infection control policies that have been developed must be implemented effectively and consistently. Placement of signage can help to remind staff of the new policies or procedures, and encourage compliance. Any equipment or supplies necessary for proper implementation (e.g., gloves to wear while cleaning cages) should be easily accessible and readily available. It is a good idea for the person responsible for implementation of infection control policies to regularly review these policies with individual employees and determine how well they remember them. 'Rewards' and recognition of employees who do particularly well

could be a motivation tool for all employees to remember and implement these procedures.

Monitoring and Assessment

Once infection control policies and procedures have been implemented, it is important to follow up by determining their efficacy and cost-effectiveness. These protocols may also need to be modified in the event of an unanticipated new pathogen or circumstance. Immediate, short and long-term goals should be established to have benchmarks for comparison.

Zoonotic Diseases

The health of the staff, volunteers and adopters is an important consideration in an animal shelter. Common hazards in this environment include physical threats such as bites or falls, chemical threats from disinfectants and other agents, and zoonoses. Zoonoses are of particular concern in the shelter environment for a number of reasons. Animals often enter shelters with unknown histories, which may include previous illnesses or exposure to infectious diseases; some of these diseases may be zoonotic. In addition, the stressors inherent in the shelter environment sometimes cause an animal to shed a zoonotic pathogen it had been carrying in a latent form. Like other infectious diseases, zoonoses can spread readily in a shelter unless stringent infection control measures are followed.

The infection control measures used to protect animals in shelters also protect human health. All staff, including volunteers, should be aware that they could acquire a disease from an animal in a shelter. They should also be trained to

recognize the zoonotic diseases commonly found in shelters within their geographic area. The sooner a zoonotic disease is recognized, the fewer people and/or animals will be exposed. Zoonotic diseases vary in severity from inapparent to deadly. The actions to take in case of a bite or other suspected exposure depend on the disease; however, they should include seeking appropriate medical assistance, notifying any appropriate authorities (shelter manager, State Veterinarian) and writing up a bite or exposure report. Rabies, one of the most severe zoonotic diseases, warrants special consideration. Rabies suspects should only be handled by experienced, rabies-vaccinated staff; pre-exposure vaccination for rabies should be strongly considered for these staff. The state health department can furnish state-specific information regarding guidelines for vaccination. Tetanus vaccinations should be up-to-date for all staff members and volunteers, including those who do not handle rabies suspects. The phone numbers for the local and state public health departments, as well as physician and veterinary contacts, should be posted in a prominent place.

Zoonoses and Immunocompromised Persons

Some zoonoses are a threat to all individuals in contact with an infected animal. Others are a serious hazard mainly to people with weakened or suppressed immune systems. An immunosuppressed person is more likely to suffer serious or even life-threatening consequences from any infectious disease, including a zoonotic one, than someone who is healthy. In addition, they may be infected more readily. The immune system can be weakened by a variety of medical conditions; the severity of the immunosuppression varies with the disease. Immunocompromised

individuals include HIV-infected individuals, transplant patients, and people with cancer, diabetes, chronic renal failure, alcoholism with liver cirrhosis, or autoimmune disorders. Splenectomy, chemotherapy, radiation therapy, chronic corticosteroid therapy, malnutrition, implanted medical devices, and long-term hemodialysis can also compromise the immune system. In addition, the immune system is generally weaker in the elderly, children under the age of five, and pregnant women (and their fetuses).

Studies show that immunocompromised individuals are not offered adequate information about zoonosis prevention, either from their physicians or veterinarians. Some of the conditions that cause immunosuppression may have a social stigma, making it difficult for a person to share his or her health information with shelter staff. Some immunocompromised individuals may not even realize the relevance of their diseases or conditions to animal contact. This makes it vital for shelter professionals to educate **everyone** about the risk and existence of common zoonotic diseases. Education should:

- Include every adopter, volunteer, foster caregiver, and staff member
- Make people aware that immune status can be affected by many conditions, and include examples of those conditions.
- Provide specific guidelines to protect immunocompromised people from zoonoses, and make people aware that this information is available.
- Provide written materials and resources for further information. Possible sources are provided below.

Consideration must also be given to shelter staff or volunteers who may have immunocompromising conditions. Measures must be taken to protect these employees from exposure to zoonotic diseases. They should not work with animals that are under one year of age, as well as those with known infectious illnesses, diarrhea, or other symptoms of a contagious disease.

Adopters with immunocompromising conditions should be aware that veterinary care should be sought early in the course of any illness their animal may have, and that routine preventative veterinary visits are essential. They should also be made aware that diligent preventative veterinary care may be expensive. While preventive measures can greatly reduce the risk of zoonoses for immunocompromised individuals, some animals should be avoided due to the high risk that they might be carrying a zoonotic parasite or pathogen. The safest choice of dog or cat for an immunocompromised adopter is an adult animal (over one year of age) that is current on its vaccinations and was surrendered from a private home. Before entering the shelter, it should have been a well-cared-for pet with no history of roaming free. The safest choice would be to facilitate the adoption of such an animal directly from its former home. Reptiles are not recommended as pets for immunocompromised people because they can carry *Salmonella*.

For more information on zoonoses and immunocompromised persons:
Centers for Disease Control and Prevention. Healthy Pets Healthy People. For People at Extra Risk. Available at http://www.cdc.gov/healthypets/extra_risk.htm.

Center for Food Security and Public Health. Zoonoses and Immunocompromised Persons. Available at: (add zoonoses website address)

Shelter Medicine Resources

In the past, shelter medicine was not a part of the veterinary curriculum, but that is changing. As interest is increasing, new shelter medicine programs, courses and continuing education opportunities are being developed. Courses in shelter medicine are now being taught at many veterinary schools, and shelter medicine residency programs have been or are being established at the University of California at Davis (UC Davis), Cornell University, Iowa State University, and Colorado State University.

Continuing education is also available. The Association of Shelter Veterinarians was established in 2001 and provides support and an E-mail list service for its members, now close to 600 strong. The UC Davis shelter medicine program and web site provide excellent practical information for shelters, and have raised the bar for all those who work in shelter medicine. The Veterinary Information Network (VIN) has offered an online course for veterinarians in shelter medicine. Veterinary conferences including the North American Veterinary Conference (NAVC) and the Western Veterinary Conference (WVC) offer tracks in shelter medicine and community health. The Humane Society of the United States (HSUS)'s Animal Sheltering magazine offers resources and information for animal shelters and rescue organizations. The first textbook on shelter medicine was published in 2004, and several others are in the works.

Canine influenza: Impact of an infectious disease in shelters

Outbreaks of disease in animal shelters may be caused by common pathogens such as parvovirus, or by novel, unexpected disease agents. The following account describes how shelters were affected when a new pathogen, the canine influenza virus, entered the canine population.

In January 2004, an outbreak of severe respiratory disease was reported in racing greyhounds in Florida. This disease was eventually identified as canine influenza, a viral disease previously unknown in dogs. The canine influenza virus, which had mutated from an equine influenza virus, was at first, a major concern mainly to the greyhound racing industry. In late 2005, canine influenza was reported in animal shelters, pet stores, boarding kennels, and veterinary clinics around the country. By September 2006, the disease had been seen in 23 U.S. states. All dogs regardless of breed or age are considered susceptible and the infection rate in canine populations can be as high as 100% since most dogs will not have immunity to this virus. While a percentage of dogs may be asymptomatic, approximately 75% of infected dogs will show signs of illness. Death from canine influenza is possible and typically occurs in dogs with severe disease; mortality rates from 1-8% have been reported.

Control measures included the isolation of sick dogs, quarantine of exposed dogs, and in some situations, the euthanasia of affected and exposed dogs. Many shelters that had the disease were forced to temporarily close to control the outbreak. These shelters lost revenue from decreased adoptions, incurred additional expenses to implement control measures, and suffered public relations

setbacks. Today, education, increased awareness, and improved infection control measures have reduced the incidence of canine influenza. However, this outbreak demonstrates that infectious diseases can spread rapidly, and may have a great impact both on animal health and on shelter operations. In addition, it highlights the importance of infection control measures for controlling both common diseases and new or emerging pathogens.

Conclusions

A good infection control plan is essential for each animal shelter. Pathogens are a constant threat to the millions of animals that enter shelters each day. In addition to known pathogens, new disease agents may emerge periodically in companion animals. Infection control measures that interrupt routes of transmission can control both new and old infectious diseases. Many of these procedures can be implemented easily. Increased awareness of these measures can greatly aid animal shelters in reducing the disease burden in animals and in protecting human health.

References

Cornell University, College of Veterinary Medicine. Test summary for canine influenza virus in dogs not affiliated with greyhound racetracks. 29 Aug 2007. Available at http://www.diaglab.vet.cornell.edu/issues/civ-stat.asp. Accessed 15 Jan 2008.

UC Davis, Koret Shelter Medicine Program. Information sheet – Canine influenza update [online]. Available at http://www.sheltermedicine.com/portal/is_canine_influenza_update.shtml. Accessed 15 Jan 2008.

Tremayne J. Canine flu confirmed in 22 states [online]. DVM Magazine; 1 Aug 2006. Available at http://license.icopyright.net/user/viewFreeUse.act?fuid=NjkyNDAx. Accessed 15 Jan 2008.

The Humane Society of the United States (HSUS). HSUS pet overpopulation estimates [online]. 12 Oct 2006. Available at http://www.hsus.org/pets/issues_affecting_our_pets/pet_overpopulation_and_ownership_statistics/hsus_pet_overpopulation_estimates.html. Accessed 15 Jan 2008.

Principles of Infection Control for Animal Shelters

Introduction

Infection control is vital in animal shelters, where newly introduced animals carry a variety of pathogens, stressed animals are vulnerable to infection and crowded conditions promote the spread of disease. Effective infection control measures can greatly minimize the spread of pathogens between animals and protect humans from zoonotic diseases. While cleaning and disinfection is often thought to be synonymous with infection control, these procedures are only one component of this multifaceted process. Equally important factors include the design and maintenance of the facility, as well as polices that maximize each animal's resistance to disease and procedures than minimize disease spread with good hygiene, barrier precautions, and isolation protocols. Each animal shelter presents unique challenges and assets, and must weigh the time, money and effort necessary to implement each measure against the risk of introduction or spread of infectious disease. This chapter provides general recommendations for infection control measures, which can be customized to develop an individualized infection control plan for each shelter. Additional details may be found at the UC Davis Koret Shelter Medicine website at www.sheltermedicine.com.

Hygiene Practices and Protocols

Hand washing is one of the most effective methods to reduce the transmission of infectious organisms. However, it is often overlooked in infection control plans. Human hands can serve as fomites, and may spread pathogens from a

single sick animal to many other susceptible animals. In addition, shelter staff and volunteers may put themselves and others at risk if they do not wash their hands before eating, touching their own mucous membranes or touching other people. Hand washing stations should be located close to animal areas to encourage this simple process and posted reminders of proper hand washing procedure, provided as a handout in chapter 5. These stations are particularly vital in animal isolation areas. Hand sanitizers may be used if sinks with running water are not available. It is important to note that if the hands are visibly dirty, hand sanitizers will have greatly reduced efficacy.

The use of barrier protection, often called personal protective equipment (PPE), reduces the risk of transferring pathogens between animals, and protects shelter staff from exposure to zoonotic organisms. PPE should be used with any animal that could be shedding a pathogen, especially if the organism could be zoonotic. It should also be used when the infection status of an animal is unknown. PPE can include gloves, protective clothing (e.g., lab coat, uniform, apron, coveralls), and in some situations, a face shield, mask and/or goggles to prevent fluids from splattering onto mucous membranes. Respirators may be necessary when dangerous zoonotic organisms are present in aerosols; however, this situation is unlikely to arise during routine nursing in a shelter. Commonly used PPE items must be readily available. Once these items have been contaminated, areas should be provided for their safe disposal or re-use. Procedures to decontaminate non-disposable clothing and other equipment should be established; these items must be washed and stored in such a way to prevent environmental contamination.

Cleaning and Disinfection (C&D)

Cleaning and disinfection, when performed properly, can reduce the incidence of infectious diseases. C&D procedures control the transmission of pathogens by most routes, but are especially important for organisms transferred by direct contact on fomites, in aerosols or from the environment. While C&D measures are used at almost all animal shelters, they are easy to perform incorrectly or inadequately. This creates a false sense of security in a shelter where ineffective procedures are in use. C&D protocols and procedures should be documented and posted for easy reference by staff. Several factors are important in the development of effective C&D protocols.

Disinfectant Selection

It is essential to select a disinfectant that is both appropriate for the pathogen(s) to be inactivated and effective in the environment it will be used in. Disinfectants vary in their ability to kill or inactivate microorganisms. Products also vary in their efficacy against specific microorganisms and in their ability to work effectively in the presence of organic debris. Some products are labeled for use as both cleaners and disinfectants.

Bleach and quaternary ammonium compounds (Quats) are the most commonly used disinfectants in shelters. Bleach is effective against many infectious agents, but it is rapidly inactivated by organic matter and exposure to light. Bleach should be stored in light-proof containers, and only freshly-made solutions should be used for disinfection. Footbaths using bleach solutions should be changed at least twice daily or more frequently if they become extensively contaminated with

organic matter. It is also important to remember that dilutions more concentrated than 1:32 can be caustic to mucous membranes, and these more concentrated bleach solutions themselves cause increased susceptibility to infectious disease. Quaternary ammonium compounds (e.g., Roccal®, Parvo-sol®, Triple-two®, Kennel-sol®) are effective against most bacteria and some viruses. They are not reliably effective against parvovirus, panleukopenia or ringworm, and are ineffective or partially effective against calicivirus. Quats can be inactivated by organic debris, but to a lesser degree than bleach.

Some disinfectants may have safety issues for personnel working with the product, or for animals that may come in contact with it. Phenolic disinfectants (e.g., Lysol ®), which are toxic to cats, should not be used in a shelter which houses this species. Personnel should wear gloves when mixing or using disinfectant solutions. They should always read the product label and follow the instructions carefully to ensure that the product is used effectively and safely. Selection of the disinfectant should be based on the product's effectiveness, cost, ease of use and toxicity to humans and animals. It is important to use disinfectants that reliably inactivate parvovirus and panleukopenia virus, which are resistant to many disinfectants and are serious threats in the shelter environment.

Proper Cleaning Procedure

The cleaning procedure itself is one of the most important and overlooked steps in C&D. Often, disinfectant is sprayed on a dirty cage and immediately wiped off in order to put the animal promptly back into the cage. However, this procedure does not allow adequate contact time for the disinfectant to work. Many

disinfectants are rendered ineffective by the presence of organic matter (e.g., dirt and feces). Therefore, objects must be cleaned before being disinfected. The type of surface (stainless steel, concrete, etc.) being cleaned is also an important consideration. Smooth surfaces are easier to disinfect than those with rough or irregular surfaces where microorganisms can hide. Cleaning solutions, such as mop water, should be changed frequently. In particular, they should be changed when they become visibly dirty or after they have been used to clean up debris from a sick animal.

A proper cleaning and disinfection protocol is detailed below. This protocol should be posted throughout the shelter to remind personnel of the importance of each step in minimizing disease transmission.

1. Remove all visible debris. (The presence of gross contamination or organic material, especially feces, will inactivate most disinfectants.)
2. Wash the area or item with water and detergent or soap.
3. Thoroughly rinse the cleaned area to remove any detergent residue. (Some disinfectants may be inactivated by detergents; therefore, it is very important to rinse well after washing the area.)
4. Allow the area to dry completely.
5. Select and apply an appropriate disinfectant.
6. Allow the proper contact time! If necessary, consult the product label. (This is one of the most overlooked steps!! The contact time may vary depending on the disinfectant selected, but is usually at least 10 minutes.).

7. Thoroughly rinse away any residual disinfectant and allow the area or item to dry completely.

Cleaning Order

Cleaning areas in the proper sequence is important to minimize disease spread and protect the animals in each area. Cleaning should always start with young, clean(er) and more vulnerable animals then move to older, less vulnerable animals. Dirtier areas or locations known to be highly infectious (e.g., isolation areas) should be cleaned last. A good flow order for cleaning is adoptable kittens/puppies first, then adoptable adult animals, stray healthy puppies and kittens, stray healthy adults, and finally quarantine and isolation areas. Cleaning protocols should also be established for additional areas of the shelter such as the lobby, hallways, office areas, and storage areas, as well as the shelter vehicles and ventilation systems. Cleaning and disinfection measures for potential fomites, such as dog toys, litter pans, etc. should also be available. Staff and volunteers responsible for cleaning should understand the importance of proceeding in the proper order and using the proper cleaning procedures.

Handling Infectious Waste

Infectious waste must be handled and disposed of appropriately. Waste should be bagged in the area where it was generated and placed in an additional bag once it is outside the contaminated area. Infectious waste must be stored securely until its removal by sanitation services, to prevent invasion by curious dogs, raccoons or other animals. Local and/or state regulations may be applicable.

Additional Considerations

After cleaning each area, staff members should change their gloves and wash their hands to minimize the possibility that pathogenic organisms might be transferred to other areas of the shelter. Ideally, staff members should change their clothing or protective outer garments between areas. If possible, each animal housing area should have its own cleaning and disinfection supplies including hoses, scrub brushes, squeegees and disinfectant applicators. Each area should also have a set of instructions for the use of cleaning and disinfection supplies. A laminated sign with detailed mixing instructions should be posted where disinfectants are mixed. Measuring supplies and personal protective equipment such as gloves, masks and protective outer garments should also be available in each area.

Each shelter, with the input of staff, should write a cleaning and disinfection protocol for its own facility, detailing the disinfectants to be used and procedures to be followed. A master copy of the cleaning and disinfection procedures and protocols should be kept in an easily accessible location. This provides a resource for personnel to consult or review as needed. The protocols for each area should address the order for cleaning within the area, the frequency of cleaning, the personnel responsible for cleaning, and the products/disinfectants to use, as well as any safety issues involved (e.g., MSDS sheets for disinfectant products). A specific staff member should be responsible for the oversight of C&D procedures and protocols within the shelter. Regular staff training on cleaning and disinfection procedures is critical, especially in shelters with high personnel turnover. Signs

placed throughout the shelter can help remind personnel of the importance of following proper C&D procedures.

For more information on cleaning and disinfection in shelters:

CFSPH Disinfection 101. Available at: http://www.cfsph.iastate.edu/BRM/resources/Disinfectants/Disinfection101Feb2005.pdf

UC Davis Koret Shelter Medicine Program. Cleaning and disinfecting in shelters information sheet. Available at: http://www.sheltermedicine.com/portal/is_cleaning.shtml#top3

Humane Society of the United States. Disinfection Connection. Animal Sheltering magazine [online]. 2003 Jul-Aug. Available at: http://www.animalsheltering.org/resource_library/magazine_articles/jul_aug_2003/disinfection_connection.html

Humane Society of the United States. Spot-Cleaning a Cat Cage. Animal Sheltering magazine [online]. 2005 May/June. Available at: http://www.animalsheltering.org/resource_library/magazine_articles/may_jun_2005/spot_cleaning_a_cat_cage.html

Seif D, Freed J. Operational Guide for Animal Care and Control Agencies: Sanitation and Disease Control. Denver; American Humane Association CR, 1998.

Miller L, Zawistowski S. Shelter Medicine for Veterinarians and Staff. Ames; Blackwell Publishing, 2004.

Animal Health

The health of an animal plays a key role in its ability to ward off infection. In a shelter, important components of health maintenance include proper veterinary care, good nutrition, stress reduction, and effective record keeping and animal identification.

Veterinary Health Care Program

A comprehensive veterinary care program is essential to maintain the health of shelter animals. Each shelter should establish an individual program based on its mission, priorities and resources. Important components of the program include

regular physical examinations, effective vaccination protocols, evaluation and treatment for parasites, and routine diagnostic testing for important infectious diseases, including heartworm disease in dogs. Daily medical rounds or observations should be considered, as they can detect any changes in an animal's health status and identify outbreaks in the early stages.

All animals entering the shelter should receive a physical examination by a veterinarian or a trained technician. The examination should be performed as soon as possible after an animal's arrival. Basic information on signalment (age, sex, breed, neuter) as well as any signs of infectious disease should be noted.

Vaccination is a critical aspect of maintaining animal health in shelters. An appropriate vaccination protocol for a particular animal will require careful consideration of the animal's history (e.g., available vaccination history, history of ownership, symptoms including injuries, pregnancy). Most shelter veterinarians agree that core vaccinations should be provided to each animal, regardless of its situation. For dogs, the core vaccines include distemper, hepatitis, parainfluenza, parvovirus and rabies. For cats, vaccinations for rhinotracheitis virus, calicivirus, panleukopenia virus and rabies should be administered. Other vaccines may be provided to dogs or cats, depending on the shelter's resources and risk factors for disease. The kennel cough (*Bordetella bronchiseptica*) vaccine is often administered to dogs, due to the high incidence of this disease in shelters.

Internal and external parasites are detrimental to an animal's health and can pose zoonotic disease risks to shelter personnel and adopters. Basic prophylactic treatment (e.g., pyrantel pamoate) for roundworms and hookworms, and a routine

fecal exam for additional internal parasites (e.g., whipworms, tapeworms and coccidia) should be conducted for all animals entering the shelter. Infested animals should be treated for any observed pathogenic parasite. Treatment prevents the spread of parasites to other animals in the shelter, avoids infestation of the shelter facilities, and reduces the risk of zoonotic disease transmission to shelter personnel and adoptive families. Due to the high risk of parasitic infection, all pregnant and nursing dogs and cats as well as puppies and kittens should be treated routinely for both roundworms and whipworms. Treatment and prevention of external parasites is equally important. Depending on the time of year and region, all incoming animals should be treated with a flea and/or tick preventative product. Additionally, the environment should be treated periodically for these parasites. If complete parasite treatment and/or testing cannot be completed within the shelter before adoption, the importance of follow-up veterinary examinations and additional treatments or tests should be conveyed to the new owner.

Signs of some infectious diseases may not be apparent when animals enter the shelter. Routine diagnostic tests for common infectious diseases should be conducted to detect subclinical disease and confirm clinical disease where appropriate. Important diseases for which to consider diagnostic testing include feline leukemia, feline immunodeficiency virus, ringworm, and heartworm. Testing for other diseases common to the area should also be considered. During an outbreak of parvovirus, panleukopenia, ringworm, distemper, or canine influenza, additional testing of exposed animals may be necessary. The shelter's mission and

level of funding will greatly determine the level of diagnostic testing that can be performed.

Medical rounds should be performed at least once daily, preferably by a veterinarian. Animals should be assessed for attitude, appetite, water consumption, vomiting or diarrhea, demeanor, and other signs of infectious disease. Staff and volunteers should use message boards to report animals in need of veterinary attention.

See the following guidelines for more recommendations on shelter animal vaccination:

American Animal Hospital Association (AAHA). 2006 AAHA Canine Vaccine Guidelines, Revised. Available at: http://www.aahanet.org/PublicDocuments/VaccineGuidelines06Revised.pdf

American Association of Feline Practitioners (AAFP). The 2006 AAFP Feline Vaccine Advisory Panel Report. Available at: http://www.aafponline.org/resources/guidelines/2006_Vaccination_Guidelines_JAVMA_%20PDF_Plus.pdf

Hurley KF. Vaccination Station: The Finer Points of Shelter Protocols. Animal Sheltering Magazine 2007 Jul/Aug. Available at: http://www.animalsheltering.org/resource_library/magazine_articles/jul_aug_2006/vaccination_station_the_finer_points.html

UC Davis Koret Shelter Medicine Program. Vaccination. Information Sheet [online]. Available at: http://www.sheltermedicine.com/portal/is_vaccination.shtml

See the following guidelines for more recommendations on parasite control in animal shelters.

UC Davis Koret Shelter Medicine Program. Parasite Control Guidelines for Animal Shelters. Information Sheet [online]. Available at: http://www.sheltermedicine.com/portal/is_parasite_control.shtml

Centers for Disease Control and Prevention. Guidelines for Veterinarians: Prevention of Zoonotic Transmission of Ascarids and Hookworms of Dogs and Cats [online]. Available at: http://www.cdc.gov/ncidod/dpd/parasites/ascaris/prevention.pdf

Record Keeping and Animal Identification

Record-keeping and animal identification can greatly aid infection control programs. These tasks allow animal movements, illnesses, treatments, and recoveries to be monitored and reviewed. Reviewing records can help identify risk factors and monitor patterns of disease, develop and assess intervention strategies, identify and respond to outbreaks, and compare data between animal shelters. Good record-keeping also allows shelter managers to analyze the budget, justify programs and identify funding issues. In addition, it is essential for determining the impact of management changes and education programs on the incidence of disease.

Each animal's records should include its identification number, description, history (if known), vaccination record, medical history and eventual disposition (adopted or euthanized). The medical history should include all diagnoses while the animal is a resident at the shelter, treatments (e.g., deworming), any previously diagnosed illnesses or conditions (if known), and the results of diagnostic tests. Throughout its stay at the shelter, each animal should wear a collar or a collar/tag combination, which should include the animal's record number. Each animal should be scanned for a microchip upon arrival. Although they can be expensive, microchips may be considered for permanent identification in animals that do not already have them.

Nutrition

Proper nutrition is essential to keep shelter animals as healthy as possible. Healthy animals have stronger immune systems, and are in better shape to resist infection or disease when they are exposed to pathogens. All shelter animals should

receive a good-quality, balanced diet appropriate for their life stage; it may include dry or canned maintenance diets, milk replacer or specialty foods for specific populations. Generic foods are not recommended because they may contain nutrients that are not easily digested or absorbed. Because some vitamins and other nutrients eventually degrade, all food should be stored properly and used within the package date. Plastic airtight containers can aid in preventing spoilage or invasion by rodents and insects. Each animal should be fed in accordance with its nutritional needs, based on its size, age, body condition and health. Excessive feeding or the use of generic feeds can increase the amount of fecal waste the shelter must manage, increasing the risk for diseases transmitted by the fecal route. Adequate amounts of fresh, clean water should always be available.

Stress Reduction and Management

Stress plays a very important role in health and disease. Stress suppresses the immune system and reduces the animal's ability to respond to pathogens. Stress has been shown to increase an animal's susceptibility to a number of important shelter diseases including parvovirus, kennel cough, coccidiosis, feline upper respiratory infection and feline infectious peritonitis. Stress can also stimulate the shedding of pathogens from latently infected carriers. Studies have shown that moving cats from cage to cage is sufficient stress to activate a latent feline herpesvirus infection.

Shelters are stressful environments. Factors that lead to stress in this setting are inherent in animal sheltering (e.g. introducing animal to a new environment) and are often difficult to control. Efforts to reduce stress can benefit all animals and

may reduce the likelihood of disease. A variety of situations can lead to stress. Animals may enter shelters with physical stresses such as malnutrition, pregnancy, lactation or injury. Once the animal is in the shelter environment, stress may occur due to its unfamiliarity with the surroundings and people. Overcrowding, noise, disruptions in routine, handling or movement (e.g., cage cleaning) and poor ventilation are additional stressors. In animals, stress can appear as behavioral problems (e.g., excessive barking, withdrawal or aggression) or illness (e.g., depression, vomiting, or diarrhea). Stress-related symptoms may mask an infectious disease or complicate its diagnosis. They can also lead to additional expenses in treating or diagnosing stress-related conditions, and could reduce an animal's chance of being adopted.

To prevent or minimize stressors in the shelter environment, consider the following measures:

- Place highly stressed animals in quiet areas.
- Establish daily routines with the same staff person performing each task.
- Provide special housing or hiding places. Cats in particular are likely to benefit from hiding places to relieve stress, particularly early in their shelter stay.
- Reduce noise levels in shelters by implementing building and structural changes, such as the application of sound absorption materials (e.g., acoustical plaster, sound-soak panels, ceiling baffles) or facility design (e.g., spaces above the ceiling or in the walls to trap noise). Experts in acoustic

design in wet environments should be consulted when designing or renovating a shelter since these surfaces will need to withstand the continual use of cleaning and disinfection products.

- Decreasing the number of animals housed in each room can also help to minimize stress from noise and overcrowding. This may be achieved by dividing large rooms and/or dividing animals into smaller groups.

Facility Design

The facility's design and management play important roles in infection control. An effective facility design allows healthy animals to be separated from those suspected or confirmed to be infectious. It also improves the efficacy of cleaning and disinfection procedures and minimizes stress for the animals. Management is important as well. Good management can mitigate the worst faults of a poorly-designed facility, while poor management practices can prevent a well-designed facility from living up to its full potential. One very important management practice is to establish and use good infection control protocols. These protocols will minimize the introduction and spread of infections in the facility on a daily basis, as well as during outbreaks. They should include written policies on intake, traffic flow, isolation, quarantine, examination and treatment. These policies provide guidance for staff and volunteers and ensure that infection control procedures will be standardized throughout the shelter.

Facility Areas

Animals enter shelters for many different reasons. Some are relinquished by the owner; others are picked up as strays, seized by law enforcement, or enter the shelter during a domestic emergency (e.g., domestic violence, home eviction), following a natural disaster, or as a transfer from another shelter. While the history of some of these animals may be known, more often it is not. To avoid the introduction of infectious diseases into the shelter and to isolate animals with different needs and conditions, facilities should ideally have the five following areas:

1. Receiving area -- where incoming animals are placed and evaluated on the day they arrive. Physical examination, vaccinations or other treatments (e.g., antiparasitics) would take place here before the animal moves to one of three areas: healthy holding, quarantine or isolation.
2. Isolation -- where incoming sick animals that require a stray hold period or animals that become sick while at the shelter are housed.
3. Quarantine -- where animals being observed for bite/rabies quarantine are housed.
4. Healthy hold -- where healthy animals are housed while they acclimate to the shelter, wait out mandated stray hold periods, or are kept while they are evaluated further.
5. Adoption area – where healthy animals that have passed behavior evaluations are put for observation and interaction with potential adopters. This area is the only one accessible to the public without a staff escort

Additionally, dogs should be separated from cats, weaned puppies and kittens from adult animals, males from females, and nursing mothers and their young from all other animals, optimally through foster-care.

Housing

Well-designed housing can reduce the introduction and spread of disease and the level of stress in the animals. Although diseases can be spread by any route in an animal shelter, the greatest threat is from transmission by aerosols, fomites or direct contact. Shelter housing designs and options have changed over the years from colonies to individual cages and back again. For disease control, individual housing is best for dogs. Group or colony housing is more common for cats and thus far, at least anecdotally, shelters that group house cats have not reported an increase in upper respiratory infections, ringworm or stress-induced illness. In fact, there may be evidence that group housing reduces stress in these cats.

The appropriate density of animals will depend on a number of factors including square footage, cage size, cage design and type of ventilation system. Overcrowding increases the environmental pathogen load as well as the stress levels, and subsequently decreases immune function. Every effort should be made to keep animal numbers at a minimum acceptable level. Leaving an empty cage between animals can help decrease disease spread and should be done whenever possible.

Dogs. Dogs confined to cages or kennels should be able to move about freely; the minimum space requirements recommended by the HSUS and the Animal Welfare Act are shown in Table 1. State requirements may also apply. Ideally,

kennels should not face one another, as the constant sight of another animal is often stressful and also increases the potential for disease transmission. Walls between dog kennels should be at least 4 feet high or higher to prevent visual or direct contact between adjacent kennels. Double-sided runs (two cages next to each other with a guillotine door in between) are optimal. This type of caging also allows for easy cleaning since the dog can be kept on one side while the other side is cleaned. This set-up allows dogs to remain in a familiar environment while cleaning occurs and prevents fomite transmission that could occur from switching cages during cleaning. Group housing of dogs should be avoided. If group housing is unavoidable due to lack of space, extreme care must be taken to observe these dogs for any symptoms of infectious disease and/or aggression. If necessary, animals less than four months of age and from the same litter or household may be housed together if no signs of infectious disease are present. Animals housed long term should be provided larger spaces and/or opportunities for daily exercise.

Table 4.1: Minimum space requirements recommended by the HSUS and the Animal Welfare Act.

Dogs	
10-35#	12 sq feet
36-50#	20 sq feet
51#+	24 sq feet
Group housing	each dog should have 4x4 feet of floor space
Cats	at least 10.8 sq feet per cat
Co-housed cats	Additional 2.5 sq feet per cat

Cats. Double-sided cages are optimal for cat housing as well. Stress and disease transmission are major factors for cats housed in the typical box type cages.

Taking cats out of cages to clean them and placing them in boxes or other cages temporarily is stressful and also increases the risk of transmission of diseases such as panleukopenia and feline upper respiratory diseases. Double sided cages help ease this stress. Limiting the number of cats per room is also important as high cat density and overall cat numbers are major risk factors for disease. Providing cats with hiding places, vertical spaces and environmental enrichment is very important to feline health. Carpeted surfaces and wood or other porous materials should be used cautiously as they are very difficult to clean and disinfect. Using feline pheromones such as Feliway® in rooms housing cats may help create a sense of well-being and calm.

Ventilation

Appropriate ventilation is extremely important for reducing airborne diseases, excessive moisture and dust, irritating gases (e.g., ammonia) and chemical fumes from disinfection products. Although designing and maintaining a ventilation system can be complicated and expensive, it is essential for infection control and animal health. One of the most important considerations is the number of air exchanges per hour (rate at which the complete volume of air inside a building or room is replaced with fresh outside air). Recommendations vary between eight and 15 air exchanges per hour but these rates may require a great deal of energy and may not be affordable for some shelters. Properly operating ventilation systems with adequate air exchanges are particularly important in crowded environments. Cat caging that is open in both the front and back may allow better airflow and decrease the buildup of infectious particles within the cage. If box type cat cages are

used, additional ventilation will be needed. Good ventilation does not compensate for overcrowding. If the recommended air exchanges cannot be delivered, decreasing the numbers of animals per square foot can minimize the concentration of airborne infectious particles and help decrease disease transmission risks. Ventilation systems must be cleaned regularly and maintained adequately. Whenever possible, three levels of air filtration are recommended in a shelter. The first level of filtration is a wire mesh to remove hair and large matter from the air. A finer filter should be placed within the air ducts to remove dust and other particulate matter. As the final stage, a HEPA filter, can remove viral particles and very fine particulate matter; however, these filters are expensive and may not be affordable for all shelters. Filters must be cleaned and/or changed frequently to prevent the buildup of pathogens. Ventilation systems also need to be inspected regularly and updated as needed.

Room Design

Lighting. Good lighting is essential for effective cleaning; areas such as the backs of cages can be difficult to see in dim light. In addition, sunshine through windows and skylights can benefit animals and shelter workers alike. Low emission glass can decrease the amount of heat entering or exiting the building through the windows. All lighting fixtures should be gasketed and waterproofed to protect them from moisture during cleaning and disinfection.

Floors, Walls and Drains. The construction and maintenance of the flooring are important considerations, since the floor will face abuse from cleaning and disinfection products, hot water and traffic from humans and animals. Most shelter

floors are concrete. A disadvantage of concrete is that it is prone to cracking with frequent temperature and humidity changes. These cracks, which are difficult to clean and disinfect, can provide areas for pathogens to hide or grow. Other flooring options that may allow for better cleaning and disinfection include methyl methacrylate, epoxy, or porcelain tiles with epoxy grout. Coving (flooring that wraps up the wall-, thus eliminating corners) helps prevent pathogen buildup in hard-to-clean areas. Many types of drains (e.g., single drains, group drains and trench drains) are found in shelters. Drains may be stainless steel, PCV or galvanized steel. When new drains are being installed, they should be placed in readily accessible areas. Drains should also be maintained properly to prevent clogging, stagnant water and the accumulation of pathogens. Drains should be at least 6" in diameter and drain covers should be used to prevent large clumps of material from entering the drain. Covers also prevent animals from getting their legs stuck inside a drain. Shelter walls are usually built of concrete blocks and coated with epoxy paints; as with epoxy floors, this surface facilitates cleaning.

Outdoor Areas, Play Areas, Dog-Walking Areas

Outdoor access is important for the health and well-being of shelter animals. However, these areas can be very difficult to clean and disinfect, and can harbor parasites or pathogens (particularly enteric pathogens). Careful consideration should be given to the choice of substrate, as the substrate will determine the amount of disinfection that can be accomplished. Gravel may be hosed down and disinfected to a degree. Dirt and grass areas can be very difficult to decontaminate. In many cases, the only option is to wait for the natural degradation of the organism

in the environment. Depending on the pathogen, this could take a long time. Wood chips or straw may be used but should be discarded if they become contaminated; while this is not a perfect option, it may help with disease prevention. All outdoor areas should receive maximum sunlight to take advantage of the disinfectant power of ultraviolet light. When possible, establishing separate areas for select groups of animals (e.g., young dogs) may help minimize the spread of disease between groups. In areas where pathogens are difficult to kill or eliminate, the best policy is to prevent contamination of these substrates. Feces should be removed from outdoor areas at least daily, and animals with diarrhea or patent parasite infestations should not be allowed to use them.

For more information on facility design see the following.

UC Davis Koret Shelter Medicine Center. Impacts of Shelter and Housing Design on Shelter Animal Health. Available at: http://www.sheltermedicine.com/portal/is_shelter_design.shtml#crowding.

Facility Management

Good management procedures are necessary for a shelter to function optimally. Some of these designs, policies and procedures have important roles in preventing or controlling infectious diseases.

Traffic

With the constant influx of animals and people in animal shelters, it is important to establish traffic patterns to minimize the spread of pathogens within the facility. Certain areas, such as the isolation and quarantine areas, should be

restricted to shelter staff. Animals brought into the clinic should be placed in a holding area and should not be allowed to venture throughout the facility.

Animal carriers can serve as fomites and should be cleaned and disinfected on a regular basis. Plastic animal carriers can become permanently contaminated when enteric pathogens become imbedded in minute scratches. Additionally, motor vehicles transporting animals to the shelter may serve as sources of pathogens if the vehicles are not cleaned and disinfected regularly.

Holding, Isolation and Quarantine Protocols

Because animals entering shelters can differ widely in health, age and background, it is essential to establish holding, isolation and quarantine protocols. These protocols allow shelter staff to assess the risks from each animal and take precautionary measures to minimize the introduction of disease. The holding time will vary, depending on each animal's situation, and may be mandated by state or municipal law. Some animals, such as healthy owner relinquishments with up-to-date vaccine histories and veterinary records, will not require much holding time. Animals without accompanying medical records may have mandatory holding times of several weeks. Long holding times may be required by circumstances or law; however, the longer an animal remains in a shelter, the greater the likelihood of it acquiring an infectious disease. Each shelter will need to determine if they have the adequate facilities and time to house these animals or whether they may be euthanized.

Isolation Protocols: Isolation is the complete separation of animals with contagious diseases from healthy animals. This segregation minimizes the transfer

of pathogens between animals, and helps prevent outbreaks. Strict infection control measures should be used in isolation areas. The number of individuals who come in contact with infectious animals should be limited; ideally, specific staff should be designated to handle these animals and clean their wastes. Other animals or people should not enter the isolation area(s). Isolation areas should be cleaned last, after other parts of the facility holding healthy animals have been cleaned for the day. Whenever possible, the cleaning should either be done by the isolation area staff or it should be the only assignment for that staff person on that day.

Quarantine (Rabies Suspect) Protocols. Quarantines mandate holding animals that may be infected with certain diseases for a specific period of time, usually as mandated by law. In shelters, animals are most often put under observation or quarantine for rabies. Quarantine times for rabies-suspects (animals that have bitten a human or another animal) are established by state regulations, but may be up to six months. A veterinarian should always be involved in the examination, observation and quarantine of an animal for rabies. Only staff vaccinated for rabies and trained to handle these animals should be involved in their care. During some types of outbreaks, an entire shelter may be quarantined in an effort to prevent the disease from spreading into the community.

Vector Control

Insects and rodents can transmit a number of infectious diseases and serve as reservoirs for pathogens. Elimination of pests is best, but not always possible. It is important to use non-toxic means of eliminating pests so as to not put shelter

animals at risk. If a serious problem exists, it might be necessary to close the shelter and place animals in foster homes while the insect or rodent pest is exterminated.

Laundry

Clothing used as barrier protection (e.g., smocks, coveralls, and scrubs), towels and blankets used in the shelter must be washed before reuse. Ideally, laundry facilities should be at the shelter's location to minimize the transfer of pathogens to other sites. Clean and dirty laundry must be separated completely. All laundry should be cleaned with soap, hot water and bleach (1/2-1 cup per load). It is important to remove as much organic matter as possible before putting the laundry into the machine, and not to overload washers or dryers. Heat from the dryer can aid in killing many pathogenic organisms. Laundry can be hung out to dry, but only in direct sunlight. Laundry used with suspected or confirmed cases of parvovirus, panleukopenia or ringworm should be discarded; because the causative organisms may not be killed by an ordinary wash/dry procedure handling this laundry may spread these diseases. Personnel doing laundry should change their clothes after handling heavily soiled laundry, and before having contact with animals or clean laundry.

For more information on Facility Management principles http://www.sheltermedicine.com/portal/is_laundry_in_shelters

Foster Homes and Additional Shelter-associated Sites

Supplementary settings, such as foster care homes or spay-neuter clinics, play important supportive roles for animal shelters. These environments should follow the same guidelines as animal shelters to prevent the introduction and

spread of infectious diseases. Personnel in these settings should be well-informed on proper infection control procedures applicable to their location.

Foster Care

Foster care programs often play a very important role in animal shelters, particularly in the care of neonatal animals. These programs need to be maintained and administered well. Foster care policies should specify the criteria used to select foster caregivers, the training they will need, and the provisions for monitoring animals and providing veterinary care. Protocols regarding fostering animals with zoonotic diseases and species-specific diseases also need to be established and should also be included in the infection control protocol for each disease. Along with advising foster caretakers on the infectious disease risk to their own pets, those providing foster care should be carefully advised of potential zoonotic disease risks to themselves and their families. Foster care training should include information on infectious and/or zoonotic disease agents and how they may be spread. Examples of diseases that should be covered include upper respiratory infection, panleukopenia, parvovirus, distemper, scabies, ringworm, rabies and *Giardia*. If a foster home experiences an outbreak or its environment becomes contaminated with a pathogen, any new animals it receives can become infected. The fostered animals could also bring the infectious disease back to the shelter, either at the time of a veterinary check-up or when the animal is supposed to go up for adoption. The latter are particular concerns with diseases that can be carried subclinically. Shelter staff should assist foster care families in identifying the proper areas to house animals within the home, based in part on the ease of cleaning and disinfection.

Spay/Neuter Clinics

Spay and neuter clinics that contract with animal shelters need to have practices and protocols for infection control in place. These infection control guidelines should be developed specifically for each clinic based on surgical protocols and funding. They should be established in conjunction with the contracting shelters to assure consistency between locations.

Infection Control in Isolation Areas

Isolation areas should be established in one or more rooms that are separated from the healthy shelter population and away from high-traffic areas. Establishing more than one isolation room allows the segregation of animals with different diseases. (i.e., animals with respiratory disease could be separated from animals with gastrointestinal disease). The doors to isolation rooms should always remain closed. Since isolation rooms will require frequent and thorough cleaning and disinfection, they should have no carpets, furniture or wood should be present in the room, as these substrates are very difficult to disinfect. Ideally, the isolation area should have a separate ventilation system. Signs should be posted to prevent the entry of unauthorized persons.

Stringent infection control practices should be used in isolation areas, to minimize disease transmission between animals and prevent pathogens from spreading to other areas of the shelter. Supplies used in the isolation area should be dedicated to this location and ideally to a specific patient. This includes supplies for cleaning, feeding and treatment. If equipment must be brought out of isolation, it should be cleaned and disinfected before removal. Each isolation area should contain one or

more hand washing stations. This will encourage compliance with infection control protocols and minimize disease transmission from the isolation area. Dedicated PPE should be worn by personnel entering these areas. The level of protection will depend on the known or suspected disease. At a minimum, gloves and protective clothing should be worn. Gloves should be discarded after use. Washable boots or shoes, or disposable shoe covers should be worn to prevent the transfer of infectious material to other areas of the shelter on footwear. Footbaths may be used as a secondary measure. They should be placed just inside the door of the isolation area and used before leaving the area. The disinfectant solution must be of sufficient depth to completely submerge the treads of footwear. Animals with zoonotic diseases should be clearly identified so that personal protection measures can be taken by their caregivers.

Only those staff essential to care for the animal(s) should be allowed in the isolation area. These individuals should be well-trained on proper infection control procedures for isolation. Staff should not eat, drink or chew gum in isolation areas.

Education

The cornerstone of infection control is education. Daily shelter activities are hectic and infection control measures can be easily overlooked unless their importance is clearly understood. Staff input should be solicited during the development of the infection control plan, and this plan must be communicated effectively to all staff and volunteers once it has been developed. Infection control protocols may appear cumbersome and time-consuming to personnel, particularly if they did not have input into the process and do not understand the importance of the specific

procedures. Shelters have high turnover rates in staff and/or volunteers, so training must be continual. In addition to discussing established infection control policies and protocols, and their importance, essential training points include the routes of transmission for pathogens, the recognition of infectious diseases, the hazards of zoonotic diseases, and the appropriate methods for cleaning and disinfection. If possible, the shelter should have one person in charge of the infection control program. This person could be the shelter veterinarian(s), the manager or a staff person. This individual should be able to oversee the development and maintenance of the infection control plan, effectively communicate the plan's components to all shelter staff and volunteers, and provide group and individual instruction on the plan. The infection control plan should be re-evaluated periodically to ensure that it remains effective, and whenever possible is improved. It is also important to encourage the staff to suggest any improvements in the infection control plan through use of a suggestion box, or other forums to give anonymous feedback. Good record-keeping is essential for this process.

Compliance is one of the biggest challenges when implementing infection control policies and procedures. Training is the first step in ensuring that these practices are followed. In addition, signs detailing infection control procedures, or where appropriate, serving as simple reminders (e.g. "Did you wash your hands?") should be posted in restrooms, intake areas, quarantine rooms, isolation areas, and kennels. These signs prompt staff and volunteers to make the extra effort to protect themselves, each other and the animals.

Conclusions

The unique nature of the animal shelter environment renders its occupants particularly vulnerable to infectious diseases, including some that can be transmitted to humans. Many people, including some shelter staff and volunteers, are not aware of the risks of infectious disease for humans and animals in a shelter, do not understand how diseases are spread, or are not aware of the measures needed to protect themselves and the animals. Implementing basic infection control measures can help prevent or control common shelter diseases, as well as uncommon, novel or emerging pathogens. Important components of an infection control plan include the design and maintenance of the facility, feeding practices and other measures that maximize the animals' resistance to disease, and procedures that minimize disease spread with excellent hygiene, barrier precautions and isolation protocols. Education of all staff, volunteers and adopters is critical to the success of these measures.

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Chapter 5: The effect of training on infection control and zoonotic disease awareness knowledge of animal shelter workers and volunteers

Introduction

One of the greatest challenges facing animal shelters is the control of infectious and zoonotic diseases. Animal shelters commonly experience high turnover of animals, high density, stressful housing conditions, and limited funding - all of which may contribute to disease introduction and spread. [33,34] Disease introduction and spread may result in increased monetary and emotional cost of caring for animals, increased antimicrobial drug use, and increased exposure of workers and volunteers to zoonotic disease. Disease transmission may end in the suffering, death or euthanasia of otherwise adoptable animals. Animal shelters function within and are closely tied to their communities. Increased or unchecked disease damages community perception and community support of their local animal shelters.

Knowledge, adoption and implementation of infection control strategies can help improve animal health. Infection control refers to a set of practices taken to prevent the introduction and minimize spread of contagious diseases into an animal shelter, as well as procedures used to control outbreaks of disease.[33] Infection control measures include knowledge of concepts of disease carriage and transmission, knowledge of clinical signs of disease, and cleaning and disinfection

concepts.[33] Infection control also includes knowledge and implementation of such practices as hand sanitation, barrier precautions, isolation, disposal of infectious waste, and development of shelter policies and protocols on vaccination and deworming and specific disease policies.[35] Zoonotic disease awareness includes not only information on the clinical signs, prevention and control of potential zoonotic disease threats, but also awareness of the role and responsibility of shelters to protect workers, adopters and potentially immune compromised individuals in any of those groups. In a recent study 90% of shelters said they would benefit from training in infectious diseases, and 88% said they would benefit from training in zoonotic disease. (Steneroden Chapter 2)

To address this need, knowledge dissemination "outreach" training for animal shelter workers and volunteers about infection control and zoonotic disease awareness should be developed. The term "outreach" is used to describe a variety of activities that extend information beyond the limits of a conventional academic setting. "Training", "intervention", "adult education", "educational intervention", "health education intervention", "knowledge-dissemination interventions", "knowledge transfer", "community-based health-education intervention" are all terms used to describe these types of activities. Different knowledge-dissemination methods have been used for educating individuals on human and animal health related matters, with varying success. Much of the animal health education research involves outreach in developing countries. Methods have included individual and community training [36-38], video [39,40], drama [36], posters [38], visual aids in general [41] leaflets, written booklet [42], diagrammatic handouts [37] as well as various

combinations of methods [36,37] which seem to suggest a multi-method approach enhances learning. [36,43] Short and long term results of knowledge dissemination methods have been examined in smallholder animal operations. [44 45 46] Although having reference material distributed and available for later reflection has been shown to be beneficial in some studies [37] other studies show that distribution of reference material only – without training and ongoing training – to be ineffective. [47] These above mentioned studies have livestock and/or developing countries as their audience and focus. These studies evaluate "knowledge dissemination" in animal health contexts and are thus illustrative of the process in general. However, the efficacy of specific methods of knowledge dissemination related to livestock health in developing countries might not be similar to the efficacy of those methods for training workers in industrialized nations about small animal health issues.

An education intervention via written booklet on dog sterilization and retention in Taiwan showed a negative effect of education on pet retention; however, the effect was reversed after a period of time [42] One study that evaluated owner education (via 6-1 hour training sessions that addressed nutrition related topics. Precise methods not disclosed) as a component of a dog obesity treatment program found no difference between groups that received conventional obesity treatment and treatment programs that included owner education. [48] A randomized controlled trial on the effect of an educational intervention (group training) with children on dog bite prevention showed a significant short term positive effect of training. [49] However, a systematic review of studies on dog bite prevention education (which included the previously mentioned study) showed no direct

evidence that dog bite education interventions reduced actual dog bites [50] and suggest that more studies need to be done. Studies measuring the effect of educational interventions in animal shelter populations have not been reported, nor have studies measuring the effect of infectious disease training in animal workers in industrialized countries. The underlying goal of all educational intervention efforts is the acquisition of knowledge and behavior change. When training shelter workers on infection control and zoonotic disease, the underlying goals are improved adoption of personal protective practices, improved shelter infection control policies, leading to decreased occurrence of animal and human disease.

The overall aim of this project was to develop and evaluate knowledge dissemination training for educating animal shelter workers on infection control and zoonotic disease awareness. The hypothesis was that infection control and zoonotic disease knowledge would change as a result of training.

Materials and Methods

Sampling frame: A previous project (Steneroden, Chapter 2) involved a shelter needs assessment survey of animal shelters in the states of Colorado, Wyoming, Montana, North Dakota and South Dakota and Utah in 2007. Seventy eight animal shelters responded to the shelter needs assessment and were included in the sampling frame for this current project.

Study Design: The study was intended to provide two outreach training sessions conducted in randomly selected animal shelters in each of the 6 states (12 total training sessions), with 10-20 participants per training session, for a total of 120-240 participants. Training included pre-training knowledge assessments;

PowerPoint[i] presentation with discussion, post-training knowledge assessment given immediately post training to assess short-term training efficacy, and a second post test knowledge assessment given to a subset of participants 2-3 weeks post training. (See appendix for training materials and tests.)

Training materials and topics: The outreach training relied on traditional lecture methods and accompanying PowerPoint presentations with extensive use of visual images. Active learning was encouraged via student participation and discussion; participants were encouraged to express their knowledge and beliefs during training. Training topics included infectious and zoonotic disease concepts and practices including modes of transmission, clinical signs of disease, incubation periods, carrier states, hand washing, barrier protection, isolation, cleaning and disinfection, 11 infectious and zoonotic diseases of concern to shelters, as well as information on zoonotic diseases and immune compromised persons. (See appendix for training materials)

Tests: Pre-tests and post-tests were administered immediately prior to and immediately after training. Pre-tests and post-tests were coded for each shelter and each individual who participated in the training. Second post-tests were mailed to shelters 2-3 weeks after training and were coded only to identify the shelter. Pre-test, post-test and 2nd post-test knowledge assessments were identical except that pre-tests included demographic information on job title, years in shelter work and years at this particular shelter. The tests included knowledge of 11 infectious and zoonotic diseases of concern in shelters: feline upper respiratory disease, plague, ringworm, panleukopenia, rabies, canine parvovirus, canine respiratory disease,

leptospirosis, internal parasites, methicillin resistant staphylococcus aureus (MRSA) and the enteric pathogens salmonella/campylobacter. Knowledge of each disease was assessed by identical questions regarding susceptible species, clinical signs of disease in animals, modes of animal-to-animal transmission, and modes of animal-to-human transmission. An identical list of thirty one different clinical signs were listed as choices for each of the diseases and scores were kept on the number of correct as well as incorrect choices. This is because learning the correct presentation of a disease may not only be associated with identifying the correct clinical signs, but also with "unlearning" beliefs about incorrect clinical signs. Unrelated to a specific disease, participants were asked questions about people at risk of zoonotic diseases, disease prevention activities, sanitation, and carrier animals. Participants were asked to identify individuals at highest risk of getting sick from a zoonotic disease. Out of a list of 23 possible choices, with 11 correct choices, participants were asked to identify 5 individuals at highest risk of illness from zoonotic disease. Participants were also asked to identify disease prevention activities by identifying 5 activities out of 10 possible choices that best help prevent disease spread in their animal shelter. Participants were asked to identify activities or ideas that are most important in shelter sanitation by choosing the 3 best choices out of a possible 8 choices. Participants were asked by multiple choice to identify all definitions of a carrier animal. A contact person at each animal shelter was sent 2nd post tests 2-3 weeks after training and was asked to give the tests to as many individuals as possible who had taken the training.

A mock training was held at an animal shelter with 7 participants to test and refine training materials and delivery. Training materials were slightly modified to include more information on clinical signs. Training was conducted over a 4 month period during the slower season in animal shelters (Jan-April) 2009 by a single author (KKS). Because of the length of training, lunch was provided to participants.

Statistical analysis: Test results were entered into an Access [ii] database and analyzed using SPSS [iii] and STATA [iv]. Descriptive analysis was performed on the results of the pre, post and 2nd post knowledge assessments. The data was evaluated for clustering at the shelter level by determining intercluster correlation coefficient (ICC) scores by ANOVA in STATA. Pre-, post- and second-post test outcomes and demographic data were evaluated for overall significance using Kruskall-Wallis [51] testing and post hoc paired comparisons made with Wilcoxon sign rank test [52] with significance values adjusted with Holm's sequential Bonferroni. [53] The level of statistical significance was <0.05.

Results

Outreach training was conducted in shelters in Colorado (6), Wyoming (2), North Dakota (1) and South Dakota (1) for a total of 10 training sessions. Shelters were contacted in the states of Montana and Utah, but none of the contacted shelters could participate during the time period of the study or they did not respond to the request for participation. Although two shelters were scheduled for training in both North and South Dakota, weather disturbances allowed for completion of training at one shelter in both states. Pre-tests were given to 111 individuals, post-tests to 111 individuals and 2nd post tests to 31 individuals.

A statistically significant difference in total scores between pre-test and post test was observed. (Table 5.2) No association was observed between test scores and length of time working in animal shelters, or with the participants' role at the animal shelter.

Identification of individuals at risk for zoonotic disease: Clustering was not significant (ICC=0.07) for the variable "identification of individuals at risk for zoonotic disease". A significant difference in the proportion of correct responses for identification of individuals at highest risk for getting sick with a zoonotic disease was observed among pretest, posttest and 2nd post test results (Table 2) On pre-test, on average trainees identified 81.2% of correct responses, on post test 91.0% and on second post test 81.3%. In Table 3 trainees identified children under the age of 5, adults over and age of 65 and HIV/AIDS patients as being at highest risk of getting sick from zoonotic disease. Fewer individuals identified those with chronic disease (heart disease 12.3%, Diabetes 15.1% and kidney disease 21.0%) as being at highest risk of getting ill from zoonotic disease. (Table 3)

Activities to help prevent disease transmission: Clustering was not significant for the activities to help prevent disease transmission variable. A statistically significant difference was not observed between pre-test and post-test scores (p=0.618). Overall, 92.8% (95% CI 89.7-96.1) of trainees identified isolation of sick animals from healthy animals, wearing gloves with sick animals 92.8% (95% CI 89.7-96.1), washing hands or using hand sanitizer 88.1 (95% CI 84.0-92.1) and disposal of infectious waste appropriately 83.7% (95% CI 79.1-88.3) as activities that can help prevent disease spread.

Ideas and activities most important to shelter sanitation: A significant difference was observed between pre-test, post-test and 2nd post test scores (p=.000) on ideas or activities most important to shelter sanitation.(Table 2) Participants correctly identified two of the top three sanitation activities "disinfect" (80.2%) and "mechanically remove all visible debris" (53.6%). On pre-test participants incorrectly identified "perfection in cleaning and disinfection should be strived for "(70.1%) over "clean using a detergent or soap" (26.4%). (Table 4) Clustering at the shelter level was present for this outcome (ICC=.335).

Identification of the definition of a carrier animal: Trainees were asked by multiple choice to identify all definitions of a carrier animal. On pre-test 66.4%, of participants correctly identified all definitions of a carrier animal; on post-test 80.2%; and on 2nd post-test the score was 93.5%. A significant difference was observed between pre-test and post-test (p=.021) and between pre-test and 2nd-post test (p=.009) on the ability to correctly identify all definitions of a carrier animal.

Identification of susceptible species to 11 infectious and zoonotic diseases: A statistically significant difference was observed between pre-test, post-test and 2nd post test on scores for the ability to identify susceptible species to 11 infectious and zoonotic diseases. (Table 5) Overall trainees identified correct susceptible species on pre-test 67.0%, on post-test 74.4% and on 2nd post test 72.8%. (Table 2)

Correct identification of clinical signs of 11 infectious and zoonotic diseases: A statistically significant difference was observed between scores on trainee ability to identify the correct clinical signs for each of 11 infectious and zoonotic diseases

on the pre-test, post-test and 2nd-post-test. (Table 6) Overall, on pre-test they identified 51.0% of clinical signs, on post-test 57.7% and on 2nd post test 66.9% of correct clinical signs associated with the 11 diseases. (Table 2)

Incorrect identification of clinical signs of 11 infectious and zoonotic diseases: A statistically significant difference between incorrect scores of trainees was observed on identification of clinical signs of 11 infectious and zoonotic diseases on the pre-test, post-test and 2nd-post-test. (Table 7) Overall, on pre-test they incorrectly identified 14.0% of clinical signs of disease on pre-test, 9.7% on post test and 6.6 on 2nd post test. (Table 2)

Identification of routes of transmission to animals: A statistically significant difference was observed between scores on the pre-test, post-test and 2nd-post-test on identification of the routes of transmission of 11 infectious and zoonotic diseases to animals. (Table 8) Overall trainees identified 66.3% of correct routes of transmission on pre-test, 80.3% on post test and 84.5% on 2nd post-test. (Table 2)

Identification of routes of transmission to humans: A statistically significant difference was observed between scores on the pre-test, post-test and 2nd-post-test on identification of the routes of transmission to humans of 11 infectious and zoonotic diseases. (Table 9) Overall trainees identified 46.7% of correct routes of transmission on pre-test, 67.7% on post test and 68.8% on 2nd post-test. (Table 2)

Discussion

Infection control and zoonotic disease awareness training is a valuable service to animal shelters. In the current study, training was successful in transferring short term knowledge to animal shelter workers.

With regard to disease information (species susceptible, clinical signs, animal transmission and human transmission) the greatest changes in pre-test and post-test scores were seen with leptospirosis, MRSA, and plague. Many of the participants commented that they knew nothing of these diseases and many had never heard the names. These are all zoonotic diseases with potentially highly significant health consequences for humans. Twenty three human cases of cat associated plague (*Yersinia pestis*) have occurred in the western states of Arizona, New Mexico, Nevada, California, Colorado, Wyoming, Oregon and Utah in the years 1977-1998. Six of those cases were in veterinarians or veterinary support staff. In addition to those that care for cats, shelters that deal with wildlife and/or have animal control officers to pick up wildlife are vulnerable and can benefit from information and updates on plague if they live in the western United States. MRSA is an emerging disease in animal populations and its prevalence is largely unknown. The American Veterinary Medical Association has recently (2008) identified MRSA as an occupational risk for veterinary professionals. [54] Awareness of its zoonotic nature, susceptible species and modes of transmission is especially important information for individuals such shelter workers who often have extensive contact with a large volume of animals of unknown medical history. Leptospirosis is considered a reemerging disease in dogs in the United States and Canada. [55] Canine cases presented to veterinary teaching hospitals have increased, potentially due to

climatic factors, serovar shifts or greater contact with wildlife. [56,57] Because of the emerging nature of these diseases shelter workers should be aware of the diseases, their clinical signs, susceptible species range and potential for zoonotic spread.

With regard to immune compromised individuals, trainees correctly identified 3 of the most often mentioned high risk individuals: children, the elderly and individuals with HIV/AIDS. Fewer recognized pregnant women as high risk and fewer still identified those with chronic disease (heart disease 12.3%, Diabetes 15.1% and kidney disease 21.0%) as being at highest risk of getting sick from zoonotic disease. This is in part due to the way the question was structured. The question had 11 potentially correct answers, but respondents were asked to choose the top 5 answers so it isn't possible to get 100% for all correct responses. Still, expanding the knowledge of animal shelter workers on the broad extent of individuals who may be at increased risk from zoonotic disease, including those with chronic medical conditions, would protect more high risk individuals from zoonotic disease.

On several of the questions the participants scored higher on the 2nd post-test than on the post-test (e.g. Table 5: Feline URI, plague, ringworm, etc.). This increase in knowledge from the immediate post test taking situation (a closed-book in-class examination supervised by one author (KKS)) to the 2nd post test situation (unsupervised take-home examinations) could have occurred for several reasons. In total only 1/3 of those taking the training also took the 2nd post test. The possibility exists that that those who opted to take the 2nd post test were more knowledgeable in the subject matter thus skewing the 2nd post test data to the higher scores.

Another possibility is that individuals taking the 2nd post test used materials they were given for the training, to complete the 2nd post test, whereas the immediate post-test was closed book

Some important limitations to this study should not be overlooked. The small number of shelters for this study might lead to insufficient power to detect potentially important effects of the training. Short follow-up period is also a limitation. Long term follow-up to include knowledge and behavior changes would be important to validate any training program. The small geographical region from which the participants were trained might limit the inference of the study.

The shelters in this study ended up being a convenience sample of those who were willing and able to participate during the time period of the study. Whether these shelters are different from shelters that could not or chose not to participate is unknown. If the participating shelters were more willing and motivated to learn new things in general, this may have been reflected in higher baseline scores and resulted in less of a difference between pre-test and post-test scores. Training may have had less of an impact in shelters with higher baseline scores. If those shelters that chose to participate had lower levels of infectious and zoonotic disease knowledge, (and thus needed/desired the training even more) this may have been reflected in lower pretest scores and greater differences in pre and post test scores and the results of training would appear more significant.

All outcomes were assessed for clustering using ANOVA; clustering was only significant for one outcome: "ideas or activities most important to shelter sanitation" and was not accounted for in the analysis. Because data within a cluster

are more alike than data between clusters, if clustering were accounted for the results of this specific analysis may not have been significant. Clustering could be evaluated using a rank sum test that accounts for clustering [58]

This research seeks to evaluate the effect of training on knowledge. Although training may increase knowledge (either temporarily or long term), whether that knowledge translated into action that protects humans and animals from infectious and zoonotic disease was not known. To really understand and evaluate the effectiveness of training, observable or measureable behaviors should be compared before and after training. Baseline knowledge of what shelter employees and volunteers know is valuable as a place to begin. Although change in knowledge is required and precedes changes in behavior or policy, knowledge change alone may not be enough. Any attempt to determine the effectiveness of training for the future should be tied with an observable outcome. These outcomes can include not only those measuring change in behavior, but also changes in behavioral intent through hypothetical scenario questions which may help predict behavior change. [40]

This outreach education evaluated one method of knowledge dissemination – in-person group training. The training however, relied on written and verbal messages with extensive use of visual images: photos and pictures and thus combined other methods of presentation. Learning is enhanced when both visual and verbal information is provided simultaneously.[43] A combination of methods of presentation is especially important when learning scientific information [43]. Participants were left with extensive notes, including disease identification and modes of transmission fact sheets as a permanent source of reference material for

study, which has been recommended by other authors.[36] Future educational programs in animal shelters might incorporate on-line learning and video as additional presentation methods; providing multiple methods overcomes the weakness of each individual method. [36]

The objective of this study was to provide outreach training in areas identified as important by animal shelters. The purpose was to provide tools so that shelters can respond to new information constructively and with innovation in the future. Effectiveness of any long term results in training will depend on supportiveness of the (shelter) environment [59] and whether those in the position of policy development will make the necessary changes to protect and improve animal and human health.

This study indicates a gap in knowledge in various aspects of infection control and zoonotic disease awareness in animal shelters that can be addressed with shelter training. Clearly this knowledge must persist and become the basis of disease recognition and prevention so as to achieve a sustainable improvement in shelter animal health. Long term retention of knowledge and the turnover of shelter workers requires on-going efforts. For the health of the animal residing in animal shelters as well as the health of those individuals working in animal shelters these gaps in knowledge should be addressed through future and expanded educational programs.

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Tables

Table 5.1: Characteristics of 110 employees and volunteers in 9 animal shelters in 4 U.S. states who participated in infection control, infectious and zoonotic disease awareness training.

Variable	Category	Number (percent)
Tests taken	Pre-test	110 (na)
	Post-test	111 (na)
	2nd post test	31
Length of time worked in shelters		
	0-6 months	37 (33.0)
	6 mo-1year	12 (10.7)
	1-2 years	11 (9.8)
	2-5 years	19 (17.0
	5-10 years	18 (16.1)
	>10 years	15 (13.4)
Role at Animal Shelter	Volunteer	27 (24.1)
	Part time paid staff	16 (14.3)
	Full time paid staff	51 (45.5)
	Other	18 (16.1)
Length of time at this shelter	0-6 mo	44 (39.3)
	6mo-1year	16 (14.3)
	1-2 years	19 (17.0)
	2-5 years	13 (12.6)
	5-10 years	12 (10.7)
	> 10 years	8 (7.1)

Table 5.2: Overall difference between pre-test, post-test and 2nd post-test scores of 110 employees and volunteers in 9 animal shelters in 4 U.S. states who participated in infection control, infectious and zoonotic disease awareness training.			
Variable (p-value)	**Category**	**Score (%)**	**Kruskal-Wallis Mean rank***
Overall scores (p=0.0001)			
	Pre-test	58.5	96.15a
	Post-test	69.5	146.81b
	2nd post-test	73.3	166.53b
Identification of high risk individuals (p=0.003)			
	Pre-test	81.2	113.64a
	Post-test	91.0	143.07b
	2nd post-test	81.3	112.81a
Identification of activities and ideas most important to shelter sanitation (p=.0001)			
	Pre-test		94.8a
	Post-test		155.38b
	2nd post-test		135.60b
Identification of susceptible species to 11 infectious and zoonotic diseases (p=0.0001)			
	Pre-test	67.0	1306.26a
	Post-test	74.4	1463.24b
	2nd post-test	72.8	1443.18b
Identification of correct clinical signs of 11 infectious and zoonotic diseases (p=0.0001)			
	Pre-test	51.0	1260.69a
	Post-test	57.7	1445.71b
	2nd post-test	66.9	1671.03c
Incorrect identification of clinical signs of 11 infectious and zoonotic diseases (p=0.0001)			
	Pre-test	14.25	1554.25a
	Post-test	9.7	1303.99b
	2nd post-test	6.6	1115.58c
Identification of routes of transmission to animals of 11 infectious and zoonotic diseases (p=0.000)			
	Pre-test	66.3	1211.40a
	Post-test	80.3	1514.37b
	2nd post-test	84.5	1603.53c

Table 5.2 continued			
Identification of routes of transmission to humans of 11 infectious and zoonotic diseases (p=0.000)			
	Pre-test	46.7	1172.59a
	Post-test	67.7	1560.66b
	2nd post-test	68.8	1574.58b
*The characters a, b, and c are used to distinguish between statistically significant mean ranks. There is a statistically significant difference between mean ranks with different characters and not a statistically significant difference between mean ranks with the same character.			

Table 5.3: Proportion of 110 employees and volunteers in 9 animal shelters in 4 U.S. states who participated in infection control, infectious and zoonotic disease awareness training that identified specified individuals as being at highest risk of getting sick from a zoonotic disease on post-test.

At risk individuals		**Percent**	**95% CI**
	Children<5 years	73.8	68.3-79.3
	HIV/AIDS	72.2	66.7-78.0
	Over age 65	69.8	64.1-75.5
	Organ transplant	47.4	41.4-53.8
	Pregnant women	46.8	40.1-53.1
	Malnourished	44.4	38.2-50.6
	Cancer patients	40.1	41.4-53.8
	Kidney disease	21.0	16.0-21.1
	Diabetes	15.1	10.6-19.5
	Heart disease	12.3	8.2-16.4

Table 5.4: Identification of activities/ideas most important to shelter sanitation by 110 employees and volunteers in 9 animal shelters in 4 U.S. states who participated in infection control, infectious and zoonotic disease awareness training.

Activity/idea	Pre-test	Post -test	2nd post-test
With the proper disinfectant you can kill anything	22/110 (20.0%)	6/111 (5.4%)*	4/31 (12.9)
Disinfection	89/110 (80.2)	89/111 (80.2)*	22/31 (70.1)*
Mixing clean/disinfecting products is usually okay	3/110 (2.7)	0/111 (0)	0/31 (0)
Perfection in cleaning and disinfecting should be strived for.	78/110 (70.1)	34/111 (30.6)*	17/31 (55.0)
Increasing the concentration of disinfectant will kill more bugs	6/110 (5.5)	1/111 (0.9)	0/31 (0)
Clean using a detergent or soap	29/110 (26.4)	77/111 (70.0)*	15/31 (48.3)*
Use the strongest disinfectant possible	38/110 (34.5)	15/111 (13.5)	7/31 (22.6

*Indicates statistically significant difference from pretest

Table 5.5: Identification of susceptible species to 11 infectious and zoonotic diseases by pre-test, post-test and 2nd post-test by 110 employees and volunteers in 9 animal shelters in 4 U.S. states who participated in infection control, infectious and zoonotic disease awareness training.

Disease	Pre-test Number (%)	Post-test Number (%)	2nd Post-test Number (%)	Kruskall –Wallis p-value
Feline URI	764/1210 (63.1)	718/1221 (58.8)*	219/341 (85.3)*	.0001
Plague	298/770 (38.7)	387/777 (49.8)*	158/217 (72.8)	.0001
Ringworm	300/440 (68.2)	291/444 (65.5)	83/124 (66.9)	.001
Panleukopenia	375/660 (56.8)	378/666 (57.8)	120/186 (64.5)	.0081
Rabies	175/440 (39.8)	246/444(55.4)	60/124 (48.4)	.9345
Parvovirus	410/550 (74.5)	428/555 (77.1)	121/155 (78.1)	.0001
CRD	520/770 (67.5)	521/777 (67.1)*	153/217 (70.5)*	.0001
Leptospirosis	166/880 (18.9)	385/888 (43.4)*	163/248 (67.4)*	.0021
Parasites – internal	314/550 (57.1	347/555 (62.5)*	114/155 (73.5)	.0001
MRSA	150/550 (19.1)	233/555 (42.3)*	93/155 (60.0)	.5361
Salmonella	386/660 (58.5)	424/666 (63.7)	126/186 (67.7)	.0001

*Indicates statistically significant difference from pre-test.

Table 5.6: Identification of correct clinical signs of 11 infectious and zoonotic diseases by pre-test, post-test and 2nd post-test by 110 employees and volunteers in 9 animal shelters in 4 U.S. states who participated in infection control, infectious and zoonotic disease awareness training.

Disease	Pre-test Number (%)	Post-test Number (%)	2nd Post-test Number (%)	Kruskall-Wallis P value
Feline URI	764/1210 (38.7)	718/1221 (58.8)	219/341 (85.3)	.0001
Plague	298/770 (38.7)	387/777 (49.8)*	158/217 (72.8)*	.0001
Ringworm	300/440 (68.2)	291/444 (65.5)	83/124 (66.9)	.0002
Panleukopenia	375/660 (56.8)	378/666 (57.8)	120/186 (64.5)	.0336
Rabies	175/440 (39.8)	246/444 (55.4)*	60/124 (48.4)*	.0001
Parvovirus	410/550 (14.5)	428/555 (77.1)	121/155 (78.1)	.0241
CRD	520/770 (67.5)	521/777 (67.1)	153/217 70.5)	.0001
Leptospirosis	166/880 (18.9)	385/888 (43.3)*	163/248 (67.4)*	.0001
Parasites – internal	314/550 (57.1)	347/555 (62.5)	114/155 (73.5)*	.0001
MRSA	105/550 (19.1)	233/555 (42.3)*	93/155(60.0)*	.0001
Salmonella	386/660 (58.5)	424/666 (63.7)	126/186 (67.6)	.0001

* Indicates statistically significant difference from pre-test.

Table 5.7: Identification of incorrect clinical signs of 11 infectious and zoonotic diseases by pre-test, post-test and 2nd post-test by 110 employees and volunteers in 9 animal shelters in 4 U.S. states who participated in infection control, infectious and zoonotic disease awareness training..

Disease	Pre-test Number (%)	Post-test Number (%)	2nd Post-test Number (%)	Kruskall-Wallis P value
Feline URI	308/2200 (14.0)	133/2220 (6.0)*	20/620 (3.2)*	.0001
Plague	574/2640 (21.7)	262/2664 (9.8)*	51/744 (6.9)*	.08
Ringworm	148/2970 (5.0)	97/2997 (3.2)*	19/837 (2.3)*	.0001
Panleukopenia	482/2750 (17.5)	425/2775 (15.3)	74/775 (9.5)*	.0001
Rabies	502/3080 (16.3)	373/3108 (12.0)*	81/868 (9.3)*	.0001
Parvovirus	473/2860 (16.5)	337/2886 (11.7)*	81/806 (10.0)*	.3433
CRD	490/2750 (17.8)	254/2775 (9.2)*	48/775 (6.2)*	.0001
Leptospirosis	309/2530 (12.1)	291/2553 (11.4)	51/713 (7.2)	.0001
Parasites – internal	356/2860 (12.4)	234/2886 (8.1)*	43/806 (5.3)*	.0001
MRSA	390/2860 (13.6)	345/2886 (12.0)	57/806 (7.1)	.0001
Salmonella	250/2750 (9.1)	202/2775 (7.3)	36/775 (4.6)*	.0001

*Indicates statistically significant difference from pre-test.

Table 5.8: Identification of routes of transmission to animals of 11 infectious and zoonotic diseases by pre-test, post-test and 2nd post-test by 110 employees and volunteers in 9 animal shelters in 4 U.S. states who participated in infection control, infectious and zoonotic disease awareness training.

Disease	Pre-test Number (%)	Post-test Number (%)	2nd Post-test Number (%)	Kruskall-Wallis P value
Feline URI	285/330 (86.4)	303/333 (91.0)	86/93 (92.5	.0001
Plague	213/330 (64.5)	252/333 (75.7)*	67/93 (72.0)	.08
Ringworm	176/220 (80.0)	205/222 (92.3)*	60/62 (96.8)*	.0001
Panleukopenia	132/220 (60.0)	181/222 (81.5)*	53/62 (85.5)*	.0001
Rabies	123/220 (55.9)	146/222 (81.5)*	43/62 (69.4)*	.0001
Parvovirus	198/220 (90.0)	202/297 (91.0)	60/62 (96.8)	.3433
CRD	269/330 (81.5)	297/333 (89.2)*	90/93 (96.8)*	.0001
Leptospirosis	122/330 (37.0)	244/333 (73.3)*	84/93 (90.3)*	.0001
Parasites – internal	139/220 (63.2)	161/222 (72.5)*	34/62 (54.8)	.0001
MRSA	147/330 (44.5)	231/333 (69.4)*	76/93 (81.7)*	.0001
Salmonella	163/220 (74.1)	185/222 (83.3)*	55/62 (88.7)*	.0001

*Indicates statistically significant difference from pre-test.

Table 5.9: Identification of routes of transmission to humans of 11 infectious and zoonotic diseases by pre-test, post-test and 2nd post-test by 110 employees and volunteers in 9 animal shelters in 4 U.S. states who participated in infection control, infectious and zoonotic disease awareness training.

Disease	Pre-test Number (%)	Post-test Number (%)	2nd Post-test Number (%)	Kruskall-Wallis P value
Feline URI	57/330 (17.3)	165/333 (49.5)*	47/93 (50.5)*	.0001
Plague	175/330 (53.0)	246/333 (73.9)*	69/93 (74.2)*	.0001
Ringworm	178/220 (80.1)	201/222 (90.1)*	58/62 (93.5)*	.0241
Panleukopenia	76/110 (69.1)	70/111 (63.1)	29/31 (93.5*)	.0001
Rabies	126/220 (57.3)	142/222 (64.0)*	42/62 (67.7*	.0001
Parvovirus	88/110 (80.1)	88/111 (79.3)	23/31 (74.2)	.0001
CRD	31/220 (14.1)	140/222 (63.1)*	33/62 (53.2)*	.0001
Leptospirosis	68/330 (20.6)	197/333 (59.2)*	57/93 (61.3)*	.0001
Parasites – internal	151/220 (68.6)	148/222 (66.7)	33/62 (53.2)*	.0001
MRSA	117/330 (35.5)	220/333 (66.1)*	69/93 (73.1)*	.0001
Salmonella	164/220 (74.5)	186/222 (83.8)*	53/62 (85.5)*	.0457

*Indicates statistically significant difference from pre-test.

[i] PowerPoint, Microsoft, Inc., Seattle Washington
[ii] Access, Microsoft, Inc., Seattle, Washington
[iii] SPSS Inc., Chicago, Illinois
[iv] STATA Corp, College Station, Texas

Chapter 6: Needs Assessment for Outreach Education Information for Animal Health Program: Surveys of Veterinarians, Farmers, Teachers, and General Public in the Republic of Armenia

This chapter combines the tools of needs assessment with an outreach program for animal health issues. Under the auspices of a program conducted through Colorado State University and the United States Department of Agriculture in the Republic of Armenia, veterinarians, farmers, the general public and teachers of school age children were surveyed to determine their needs and desires for outreach education on their national animal health program. The central hypothesis of this project was that needs and preferences for outreach would vary by group. Specific aims included surveying groups individually to ascertain their needs and preferences for information on their national animal health program and to tailor outreach to each group. The results of this project provided the basis for development of outreach materials for veterinarians, farmers, the general public and school-age children in Armenia.

Introduction

In the early 1990's the economic situation in the former Union of Soviet Socialist Republics (USSR) shifted dramatically. The change from a centrally planned economy had tremendous impact on agricultural communities. [1] Rural poverty increased and large collective farms were replaced by a mixture of corporate farms, family and backyard farms. [1] These new farmers had little husbandry knowledge or

experience, which resulted in decreased production, premature slaughter of animals and a substantial decrease in livestock. [1] The change to backyard farming led to greater contact between humans and animals and an increase in a number of zoonotic diseases in the human population including Q fever, [2] echinococcus, [3] rabies [4] and brucellosis. [5].

Veterinarians, who once served the collective farm and were paid by the state, had little knowledge of or experience serving the private farmer. Veterinarians under the Soviet system focused on food animals and selected infectious diseases with little attention paid to production diseases. [1] Veterinarians were a product of a veterinary education system based on theory over practical experience; had limited skill and knowledge of epidemiology, and had no exposure to modern developments in animal health. [1] Veterinarians lacked equipment, access to supplies and drugs, received little or no continuing education and were unfamiliar with business practices necessary to establish private veterinary practices. [1, 6]

Significant differences exist in the animal health systems among the former Soviet republics. These differences include veterinary capacity, reforms already enacted since the breakup of the USSR, proximity to western markets, wealth and resources. [1] The changes needed in the former Soviet republics will vary depending on the country and their specific legacy with communism. One important similarity among these countries is a farming community that is literate and often well educated. [1] To determine appropriate content for educational interventions, local veterinarians, farmers and other stakeholders must be consulted. Services provided

to individuals are only effective when they meet real needs and when the stakeholders agree that they have those needs. [7]

The obstacles facing these transitional countries, their governments and their veterinarians as they seek to develop and enhance their national animal health are great. Through a joint project established by the Animal Population Health Institute of Colorado State University and the United States Department of Agriculture (USDA), 3 diversified pilot areas in Armenia are being established and supported as sites for focused animal health enhancement efforts. The 3 pilot areas in Armenia will be used to evaluate husbandry, disease status and animal health practices in diverse communities, and to test animal health management plans. The long-term goals for these pilot areas are to raise the level of animal health, raise the level of knowledge of farmers and to assist veterinarians in gaining skills and knowledge necessary to better perform their jobs and to gain respect within their communities. Short term demonstration projects such as the current project help gain local support which can help facilitate project expansion in the future. [1] Training and workshops for veterinarians and farmers must meet their specific needs and desires. Information on public health and biosecurity will be infused within the trainings. Whenever possible, training and workshops will be through local veterinarians who have knowledge or have received advanced training on specific topics of local interest.

The purpose of this study is to survey veterinarians, farmers, teachers, and the general public regarding their needs and desires for animal health training in the Republic of Armenia.

Methods

Surveys were developed and then distributed to the heads of the Agricultural Support Center who recruited members from each of the 4 groups (community veterinarians, farmers, general public and teachers of school age children) to take the survey in the Kotyak and Aragatsotn Marzes in the Republic of Armenia during the summer of 2007. (See Figure 1) The surveys were translated into Armenian, given to the participants; the results translated into English and entered into an Excel database[i]. Surveys were taken of 18 community veterinarians, 19 farmers, 19 members of the general public and 18 public school teachers. Community veterinarians were asked questions to determine their desires for training and best methods of delivery of that training. Community veterinarians were also asked about the importance and perceived threat of zoonotic diseases, food safety issues and their role in ensuring food safety in Armenia. They were also asked what they believe farmers need in the way of training, how to best deliver that training and what methods and materials will best help them, as veterinarians, train farmers.

Farmers were asked questions to determine their desires for training, best methods of delivery of that training and their likelihood of attending training. Farmers were also asked about the importance and perceived threat of zoonotic diseases, food safety issues and their role in ensuring food safety in Armenia.

The general public was asked questions to determine their desire for information on their national animal health program and how to best deliver that information to them. They were also asked about the perceived threat of zoonotic

diseases, food safety issues and the role of veterinarians, farmers and government in ensuring food safety.

Questions were closed and used a 3 or 4 point Likert scale (very important, important, not important, no opinion) or (strongly agree, agree, disagree), depending on the question. Ample room was left after each question for individual comments.

Teachers of children aged 6-17 years were asked open-ended questions to determine what children are currently being taught about their national animal health program, food safety, and zoonotic diseases. Teachers were asked to comment on the appropriate age for inclusion of this information in the curriculum, appropriate places or courses to add this information and whether educational materials put together on these topics would be welcome in the curriculum.

Results

Community Veterinarian Surveys: Veterinarians (n=18) were most interested in information on animal diseases followed by zoonotic disease information, food safety and lastly biosecurity information. (Table 1) In-person training sessions were preferred with pamphlets and poster handouts. (Table 2) Fewer than half of the veterinarians surveyed reported that zoonotic diseases are a great concern to them. (Table 3)Within food safety, microbial pathogens in food were the most important concern; antimicrobial residues in food, water quality and food importation were slightly less important; and food production and farm biosecurity considered least important for food safety. (Table 4)

Veterinarians believed that farmers need training first on zoonoses, then food safety, animal diseases and lastly biosecurity. (Table 5) Veterinarians believed farmers would best learn through in-person training sessions with handouts delivered by community veterinarians, as well as TV and radio programs. (Table 6) In order for veterinarians to train farmers, training manuals/fact sheets/pamphlets and posters geared towards farmers were most desirable. (Table 7) (See Brucellosis and FMD factsheets, brochures and posters developed for veterinarians in appendix) Veterinarians believed that farmer training should be in plain, easily understood language and include practical information for farmers in addition to the information provided on the National Animal Health Program (NAHP). Because veterinary services are expensive, these seminars were perceived as a very useful and affordable way for farmers to get information. (Table 7) The top 3 zoonotic diseases of concern to veterinarians were brucellosis, tuberculosis and anthrax. (Table 8) Veterinarians believed that the government has the most important role in ensuring food safety. (Table 9)

Farmer Surveys: Farmers (n=20) were most interested in information on zoonotic diseases followed closely by animal disease information, food safety and lastly biosecurity. (Table 10) Disease fact sheets/pamphlets and posters were important methods for farmers to learn about the NAHP followed by radio and TV farm shows and in-person training delivered by community veterinarians. (Table 11) (See also Brucellosis and FMD factsheets, brochures and posters developed for farmers in appendix) Half of the farmers surveyed believed that zoonotic diseases are a great concern to farmers. (Table 12) Water quality was considered the most

important element of food safety, followed by microbial pathogens, antimicrobial residues and lastly production practices and farm biosecurity. (Table 13) Farmers believed that veterinarians have the greatest role in ensuring food safety. (Table 14) Almost all farmers reported that if offered, they would attend training of this sort.

Comments by farmers were that the addition of animal care and feeding information would be welcome and that seminars need to be held more often and involve more members. The top three zoonotic diseases of concern to farmers were anthrax, brucellosis and tuberculosis. (Table 15)

General Public Surveys: The general public (n=19) was most interested in learning the basic elements of the NAHP followed by zoonotic disease information. (Table 16) Informational sessions delivered by veterinarians and TV or radio shows were reported to be the best methods to deliver the message to the general public. (Table 17) The general public believed that farm biosecurity is a very important aspect of food safety followed by microbial pathogens in food, food importation and antimicrobial residues and water quality. (Table 18) The general public believed that the government has the most important role in ensuring food safety (Table 19) and that zoonotic diseases were a threat to the general public and farmers over veterinarians. (Table 20)

Comments included that consulting organizations, not only the local veterinarians should hold seminars as they felt it is very important to have consultations with professionals. Comments made by many were that any issues that concern human health is of a great importance. Several mentioned that the veterinarian is responsible for procedures, the farmer for finding the infected

animals and the government for providing medications and vaccines that would be necessary. (Table 17)

Teacher Surveys: Eighteen teachers were surveyed. It was not clear from the survey what children are currently being taught about their national animal health program. (Table 21) Children were taught about food safety in biology and healthy lifestyle courses where they learn about food preservation and washing fruits before using. Teachers reported that not enough information about food safety is provided in classroom books and that children only learn a limited number of things about food safety. When asked what children are being taught about zoonotic diseases, 7/18 responded that little or no information is given to children and that more attention must be paid to this issue. Teachers commented that children learn to avoid animals that are infected and not use their products. Children learned how to behave with animals and that the village veterinarian often has a conversation with students about transmissible diseases.

Teachers reported that the best methods to help inform students on these issues were in-class presentations by experts and/or veterinarians, followed by games/puzzles/activity books related to animals and animal health. (Table 22)

The majority of teachers believed that the most appropriate age to teach children information on their national animal health program, zoonotic diseases and food safety is age 10-15 years. However, several teachers commented that this type of information should begin when the child first enters school, especially in the rural areas. Complementary courses where this type of information could be included are biology, healthy lifestyle, and environmental protection courses. Most teachers were

very eager to have information on these topics to use in the classroom. When asked if educational materials and a short program were put together on these topics would it be a welcome addition to your curriculum, teachers responded positively. Teachers responded that they were "eager to have this information", "it would be very useful" and "must be done for sure".

Discussion/Recommendations

Veterinarians and farmers reported that basic biosecurity information was less important than animal disease, zoonotic disease and food safety information. This contrasts with the general public, who were more concerned about farm biosecurity than veterinarians and farmers. Biosecurity plays a central and essential role in animal health and disease prevention, zoonotic disease prevention and food safety. The Federation of Veterinarians of Europe, the European trade organization of veterinarians has embraced the need to promote and improve on-farm biosecurity and much can be achieved by raising knowledge and awareness of risks and changing attitudes towards risks. [8] Even before "best biosecurity practices" are taught, practical and relevant examples on the importance of biosecurity to animal and human health in Armenia need to be stressed.

All surveyed groups believed that in-person training sessions and/or disease fact sheets/pamphlets, posters were very important methods for informing on the NAHP. Television/radio, farm shows, commercials were also mentioned as being very important by all groups. Different knowledge dissemination methods have been used for educating individuals on human and animal health related matters with varying success. Much of the research involves outreach in developing

countries. Methods have included individual and community training, [9-11] video, [12,13] drama, [9] posters ,[11] visual aids in general ,[14] leaflets, [9] diagrammatic handouts [10] and various combinations of methods [9,10]. Many researchers believe that a multi-method approach may work best. [9,15] Learning is enhanced when both visual and verbal information is provided simultaneously thus overcoming the weakness of any individual method.[15] Future education programs might incorporate community, in-person training along with sheets/pamphlets and posters to further explore this multi-method approach. Computer based presentations were given much less importance. This may be due to lack of exposure to computer based learning which may be overcome in the future with increased introduction and accessibility of technology.

Farmers and veterinarians agreed that farmers want and need practical animal husbandry information in addition to NAHP information. Extension programs would be the likely avenue for such knowledge transfer. However, extension programs did not seem to be highly desired or considered important. If extension programs did exist in a particular country under the Soviet system, they did not serve the needs of the new smallholder farmer. [1] Extension programs can be an efficient way to organize information and reach farmers and veterinarians. Development of extension services to support the new small scale livestock system as well as veterinarians would be necessary components of any enhancement to national animal health.

All groups believed that farmers and the general public are more threatened by zoonotic diseases than veterinarians. Is the lack of concern for the threat of

zoonotic diseases to veterinarians well founded? Examination of human health data to determine the level of zoonotic disease in veterinarians compared to farmers and the general public could be informative to all groups.

Differences exist in the needs and desires for education and training in former Soviet countries. An assessment of needs should be performed prior to initiation of programs so that they can be geared towards the local community.

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Tables

Table 6.1: Survey of 18 Armenian veterinarians on the importance of topics in veterinarian training on their NAHP.

How important are these topics in your training?	Very important	Important	Not important	No opinion
	Number	Number	Number	Number
Diseases included in the NAHP (Including disease identification, transmission, diagnosis, prevention and control)	18/18	0	0	0
Zoonotic diseases of concern in Armenia (Including disease identification, transmission, diagnosis, prevention and control)	16/18	2/18	0	0
Basic biosecurity/infection control practices (Including farm and perimeter, people and vehicles, record keeping, animal health, cleaning and disinfection)	11/18	7/18	0	0
Food safety issues (Including microbial pathogens in food, antimicrobial residues in food, water quality, production practices, food importation)	15/18	3/18	0	0

Comments:

- It's very important to hold such seminars; one member from each family mu participate.
- With the help of these classes, it will be possible to provide information abo diseases.
- These seminars are necessary to manage diseases, to communicate with far and give them instruction.
- It is important for the society to realize the seriousness on these diseases.

Table 6.2: Survey of 18 Armenian veterinarians on the importance of methods for veterinarians to become informed on issues relating to the NAHP.

The following are important methods for veterinarians to become informed on issues relating to the NAHP.

	Strongly agree	Agree	Disagree
In person training sessions	16/18	2/18	0
Training manuals	9/18	9/18	0
PowerPoint presentations	2/18	12/18	4
Fact sheets/pamphlets/posters	9/18	9/18	9/18

Comments

- To provide as much professional information as possible, newspapers and hand outs
- It's very important to get advice during the classes
- TV and Radio programs would be very useful for informer larger amount of people
- Any new method that shows a new approach, and is very important
- Have seminars with current working staff and people responsible for the farm

Table 6.3: Survey of 18 Armenian veterinarians on the threat of zoonotic diseases to veterinarians, farmers and the general public in Armenia.

Zoonotic diseases in Armenia are a threat to:

	Strongly agree	Agree	Disagree
Veterinarians	7	4	7
Farmers	13	5	0
General public	13	5	0

Comments:

- Transmissible diseases are very dangerous for every member of our society.
  Farmer is the 1st one dealing with the animal, so I agree that the 1st danger is for the farmer and he should be more careful.
- If people are not aware, they can easily get bad diseases
  For smallholders infectious diseases cause a great amount of damage in importing and exporting.

Table 6.4: Survey of 18 Armenian veterinarians on the importance of food safety issues in Armenia.				
How important are these food safety issues in Armenia?				
	Very important	**Important**	**Not important**	**No opinion**
Microbial pathogens in food (e.g. salmonella, campylobacter, e.coli)	16/18	2/18	0	0
Antimicrobial residues in food	12/18	6/18	0	0
Water quality	12/18	6/18	0	0
Production practices	10/18	8/18	0	0
Farm biosecurity	7/18	11/18	0	0
Food importation	12/18	6/18	0	0
Comments: • All of these issues are very important for food safety provision in Armenia. • When animals are healthy, food products are safer. • Before getting to the consumer, the food both imported and national must u Food Safety inspections.				

Table 6.5: Survey of 18 Armenian veterinarians on the importance of topics in farmer training on the NAHP.

How important are inclusion of the following topics in farmer training on their NAHP?

	Very important	Important	Not important	No opinion
Diseases included in the NAHP (Including disease identification, transmission, diagnosis, prevention and control)	12/18	6/18	0	0
Zoonotic diseases of concern in Armenia (Including disease identification, transmission, diagnosis, prevention and control)	15/18	3/18	0	0
Basic biosecurity/infection control practices (Including farm and perimeter, people and vehicles, record keeping, animal health, cleaning and disinfection)	7/18	11/18	0	0
Food safety issues (Including microbial pathogens in food, antimicrobial residues in food, water quality, production practices, food importation)	13/18	5/18	0	0

Comments

- Giving the correct diagnosis and preventing the disease on time will preven development. That way we will have fewer damages.
- The farmers need enough knowledge about these issues as they are the one will detect disease and tell the veterinarian.
- Each farmer who deals with animals must know about the mentioned issues
- It is important to include information that is typical for that particular regio
- Besides the farmers, other farm workers should also be involved in these seminars.

Table 6.6: Survey of 18 Armenian veterinarians on the importance of methods for farmers to become informed on issues relating to the NAHP.			
The following are important methods for farmers to become informed on issues relating to the NAHP.			
	Strongly agree	**Agree**	**Disagree**
In person training sessions delivered by community veterinarians	11	7	0
Training manuals	10	8	0
PowerPoint presentations	0	13	3
Fact sheets/pamphlets/posters	8	10	0
TV/radio farm shows	11	7	0
Extension programs through the university	7	11	0
Comments: • Not only the veterinarians but also the consulting organizations and scientists should hold such seminars for farmers.. • TV and Radio programs and consultations with the veterinarian are easier to understand • With providing useful information we can provide a safe production of food.			

Table 6.7: Survey of 18 Armenian veterinarians on the importance of methods available to help veterinarians train farmers on NAHP issues.

How important is the availability of these methods for you to help to inform farmers on NAHP issues?

	Very important	Important	Not important	No opinion
Power point presentations using computer	4/18	11/18	3/18	0
Training manuals in a form of papers	11/18	7/18	0	0
Fact sheets/pamphlets and posters	11/18	7/18	0	0

Comments:

- Practical seminars on such issues as injections, diagnosis, etc. are important
- Newspapers and hand outs written in a simply written way for farmers wo be appreciated.
- The community farmer should always be informed about the changes in the
- As the veterinary consultations are not always affordable, these seminars a
- Each of them have their advantages

Table 6.8: Survey of 18 Armenian veterinarians on importance of zoonotic diseases in Armenia.

How important do you believe are the following zoonotic diseases in Armenia?

	Very important	Important	Not important	No opinion
Anthrax	13/18	1/18	1/18	1/18
Avian influenza	13/18	1/18	1/18	1/18
Brucellosis	14/18	0	1/18	1/18
Cryptosporidium	6/18	7/18	0	3/18
Cysticercosis	6/18	7/18	1/18	2/18
Echinococcus	12/18	2/18	1/18	1/18
Leishmaniasis	7/18	5/18	3/18	1/18
Leptospirosis	7/18	7/18	1/18	1/18
Listeriosis	6/18	8/18	1/18	1/18
Orf	10/18	4/18	1/18	1/18
Q fever	8/18	3/18	3/18	2/18
Rabies	11/18	2/18	1/18	1/18
Salmonellosis	11/18	3/18	1/18	1/18
Tuberculosis	14/18	0	1/18	1/18
Tularemia	10/18	4/18	1/18	1/18

Comments:

- All of them are dangerous, and it's necessary to keep society aware because they affect human health.
- Timely vaccination is important to prevent such diseases.

Table 6.9: Survey of 18 Armenian veterinarians on the importance of veterinarians, farmers and the government in ensuring food safety.

In ensuring food safety how important is the role played by:

	Very important	Important	Not important
Veterinarians	12/18	6/18	0
Farmers	12/18	6/18	0
Government	15/18	3/18	0

Comments

- I would also like to add the consumers and the sellers of products. The food product can get spoiled but still given to the consumer.
- Veterinarians play a great role as they are the ones who do the injections an other procedures.
- Each county must have one Lab for food safety
- All of them are very important
- The government must provide the food safety measures; the farmers should take care of the family and in case of something immediately let the veterinarian know.
- The farmer, the veterinarian and the government must work together, starti from providing medication, finance and vaccines.

Table 6.10: Survey of 19 Armenian farmers on the importance of topics in training on their NAHP.

How important are these topics in your training?	Very important	Important	Not important	No comment
Top 3 diseases included in the NAHP (Including disease identification, transmission, diagnosis, prevention and control)	17/19	1/19	0	1/19
Zoonotic diseases of concern in Armenia (Zoonotic diseases are those that can be transmitted from animals to humans. Information would include disease identification, transmission, diagnosis, prevention and control)	18/19	1/19	0	0
Basic biosecurity/infection control practices (Including farm and perimeter, people and vehicles, record keeping, animal health, cleaning and disinfection)	15/19	4/19	0	0
Food safety issues (Including microbial pathogens in food, antimicrobial residues in food, water quality, production practices, food importation)	16/19	3/19	0	0

Comments:

I would also add the issues of animal care and feeding.

- Each farmer must learn about the animal diseases, especially the ones concerning his animals and about the danger of the transmissible viruses (2)
- It is the farmers job to fight and prevent the infectious diseases so they have to be very careful
- Seminars on such issues will be more effective if they are held more often and involve more members.

Table 6.11: Survey of 20 Armenian farmers on the importance of methods to become informed on issues relating to their NAHP.

The following are important methods for you as a farmer to become informed on issues relating to the NAPH, zoonoses, biosecurity and food safety.

	Very important	Important	Not important	No comment
In person training sessions delivered by community veterinarians	11/20	7/20	0	2/20
Training manuals	8/20	11/20	0	1/20
Disease fact sheets/pamphlets/posters	14/20	4/20	0	2/20
Computer based presentations	1/20	15/20	2/20	2/20
TV/radio farm shows	11/20	7/20	0	2/20
Extension programs through the university	6/20	11/20	1/20	2/20

Comments:

- Only with the help of classes and seminars it will be possible to inform the p about the level of danger for these diseases
- In the world of modern technology it is important to be aware of diseases.
- The farmer will with more pleasure listen to the veterinarian or watch TV pr
- Often have TV and Radio Programs for our information
- All of these methods will help to be aware of the diseases and prevent them i

Table 6.12: Survey of 20 Armenian farmers on the threat of zoonotic diseases to veterinarians, farmers and the general public in Armenia.				
	Strongly agree	**Agree**	**Disagree**	**No answer**
Zoonotic diseases in Armenia are a potential threat to:				
Veterinarians	3/20	10/20	5/20	2/20
Farmers	10/20	7/20	1/20	2/20
General public	10/20	7/20	1/20	2/20

Table 6.13: Survey of 20 Armenian farmers on food safety hazards in Armenia

Food safety refers to all hazards that could make food unsafe to the consumer. How important are the following food safety issues in Armenia?

	Very important	Important	Not important	No comment
Microbial pathogens in food (e.g. salmonella, campylobacter, e.coli)	16/20	2/20	0	2/20
Antimicrobial residues in food	13/20	4/20	0	3/20
Water quality	18/20	0	0	2/20
Production practices	7/20	11/20	0	2/20
Farm biosecurity	13/20	5/20	0	0
Food importation	12/20	5/20	0	3/20

Comments:

- The food must be under strict control until it gets to the consumer.
- I think it's important, as there's not much information about the mentioned i
- Any information given to the farmer should be easy to understand and also i
- All of the mentioned issues are very important for food safety provision (2)
- It's much easier to prevent then to cure the diseases
- When importing food products, surveillance by the professionals is importar
- Inspections and other measures of fighting diseases must be taken more ofte
- These issues are very important and seminars should be held more often

Table 6.14: Survey of 20 Armenian farmers on the importance of the role played by veterinarians, farmers and government in ensuring food safety.

In insuring food safety how important is the role played by:

	Very important	Important	Not important	No comment
Veterinarians	14/20	4/20	0	2/20
Farmers	12/20	6/20	0	2/20
Government	11/20	7/20	0	2/20

Comment:

- I would add that the role of intermediary organizations
- The veterinarian is responsible for procedures, the farmer for finding the infected
  animals and the government-for providing medications that would be necessary.
- Every single person plays its part in producing healthy food for people
- All of them are important (2)
- It's also important that the consumers don't buy food from suspicious places
- Everyone should do his job properly
- I think all of them play an important role in providing food safety, especially the Government.

Table 6.15: Survey of 20 Armenian farmers on the importance of zoonotic diseases in Armenia.

How important are the following zoonotic diseases?

	Very important	Important	Not important	No comment
Anthrax	17	1	0	2
Avian influenza	15	2	0	3
Brucellosis	15	2	0	3
Cryptosporidiosis	6	8	0	5
Cysticercosis	10	7	0	3
Echinococcosis	11	6	0	3
Leishmaniasis	8	9	0	3
Leptospirosis	8	8	0	4
Listeriosis	8	8	0	4
Orf	10	6	0	4
Q fever	12	5	0	3
Rabies	14	2	0	4
Salmonellosis	10	7	0	3
Tuberculosis	15	2	0	3
Tularemia	9	8	0	3

Comments:

- All the diseases are infectious and important, so society must be made aware them. (3)
- It is necessary to have a strategy for fighting such diseases

Table 6.16: Survey of 19 members of the general public in Armenia on the importance of inclusion of various topics in their NAHP training.

In information that becomes available to you on Armenia's National Animal Health Program how important are inclusion of the following topics

	Very important	Important	Not important	No answer
The basic elements of the NAPH (Long and short term goals of the program, important diseases, role of government and veterinarians, etc.)	17/19	0	0	2/19
Zoonotic disease information (Zoonotic diseases are those that can be transmitted between animals and humans)	16/19	1/19	0	2/19

Comments:

- For all the community members it is important to learn about these issues
- The water quality and the food ingredients must be checked very frequently, and introduced at frequent seminars. (4)
- If people are aware of these diseases, they can easier prevent them
- Seminars should be held more often and involve more members of society (2)

Table 6.17: Survey of 19 members of the general public in Armenia on the importance of methods of becoming informed on issues of the NAHP.

The following are important methods for the general public to become informed on issues relating to the NAPH, zoonoses, and food safety.

	Very important	Important	Not important	No answer
Informational sessions delivered by veterinarians	16/19	1/19	0	2/19
Disease fact sheets/pamphlets/posters	10/19	7/19	0	2/19
Computer based presentations	2/19	14/19	0	3/19
TV/radio shows/commercials	11/19	5/19	0	3/19

Comments:

- Not only the vet, but also consulting organizations should hold seminars (2)
- The classes are very important and useful (2)
- It is very important to have consultations with professionals (3)

Table 6.18: Survey of 19 members of the general public on the importance of food safety issues in Armenia				
Food safety refers to all hazards that may make food unsafe to the consumer. How important are the following food safety issues in Armenia?				
	Very important	**Important**	**Not important**	**No answer**
Microbial pathogens in food (e.g. salmonella, campylobacter, e.coli)	16/19	1/19		2/19
Antimicrobial residues in food	14/19	2/19		2/19
Water quality	14/19	2/19	0	2/19
Production practices	3/19	14/19	0	2/19
Farm biosecurity	17/19	0	0	2/19
Food importation	15/19	1/19	0	3/19
Comments: • Any issue that concerns human health is of great importance.				

Table 6.19: Survey of 19 members of the general public in Armenia on the importance of the role played by veterinarians, farmers and government in food safety.

In insuring food safety how important is the role played by:

	Very important	Important	Not important	No answer
Veterinarians	15/19	2/19	0	2/19
Farmers	15/19	2/19	0	2/19
Government	17/19	0	0	2/19

- All of the mentioned in its sphere is important in providing healthy and safe food for the society (4)
- The veterinarian is responsible for procedures, the farmer for finding the infected animals and the government for providing medications and vaccines that would be necessary (3)
- Government had the leading part (2)

Table 6.20: Survey of 19 members of the general public in Armenia on the threat of zoonotic diseases in Armenia.

Zoonotic diseases in Armenia are a potential threat to:

	Strongly agree	Agree	Disagree	No answer
General public	12/19	2/19	0	5/19
Farmers	12/19	4/19	0	3/19
Veterinarians	4/19	0	8/19	7/19

- The immediate connection is between the farmers and animals
- The veterinarian must be aware of the farm conditions and if the disease has already transmitted to a farmer,
- Transmissible diseases are always a danger (2)
- The farmers and the community members don't know much about the diseases, and the can easily get infected
- The veterinarian is a professional, and he uses all necessary tools, so there is less danger for him. (5)

Table 6.21: Survey of Armenian teachers on need for student training on the NAHP.
What are children in your school currently being taught about their <u>national animal health program?</u>
• Children get information during the classes of zoology/biology/healthy lifestyle (5) • Not taught/nothing in the program (4) • Not dealing with a sick animal • Only some of the issues • About the transmissible diseases and also how to fight them • At 6-7 grades children learn about hygiene and about diseases
What are children in your school currently being taught about food safety? (e.g. hand washing, Proper food temperature, safe food handling, etc.)
• Not enough information in class books (2). • Nothing in the program/not taught (2) • Biology and Health Lifestyle classes teach how to preserve food and food safety and washing fruits before using (7) • The students learn about the product use and the quality, and hygiene • Students learn about the importance of paying attention to the date of expiry of the product and washing before using • Only few things (2)
What are children in your school currently being taught about <u>zoonotic diseases</u>? (Zoonotic diseases are those that can be transmitted between animals and humans such as rabies, brucellosis)
• Very little information, in a few hours (3)
• Nothing in the program/ not taught (3)
• More attention must be paid to this issue
• During the classes of Zoology/Life skills (2)
• Not dealing with animals that are infected or using their products
• We talk to students about how to behave with animals
• The village veterinarian often has conversation with students about transmissible diseases
• At the classes of 5-7th Biology there are materials on these issues, also we have class-masters hours for discussing such things
Are similar topics being taught which would be complementary to this information?
• No (4) • Yes (2) • There is not enough information in class books • Such issues are examined at classes of Biology (2) • The class of healthy lifestyle teaches about these issues also • We have classes of Environmental protection and we globally talk about such problems

Table 6.21 continued
If educational materials and a short program were put together on these topics, do you think it would be a welcome addition to your curriculum?
• It would be great to include such issues in teaching programs • I encourage such seminars or after class lessons, It's very useful • I would like to have literature on these issues, and I encourage such things • We are eager to have classes on all of these issues • Any novel thing is encouraging • We would like to include such issues in teaching materials • Yes (2) • Yes, I strongly encourage, it must be done for sure (2)

Table 6.22: Survey of 18 Armenian teachers on the importance of methods for children to become informed on issues relating to the NAPH, zoonoses and food safety.

	Strongly agree	Agree	Disagree
The following are important methods for children to become informed on issues relating to the NAPH, zoonoses, and food safety.			
In class presentation by experts and/or veterinarians	12/18	6/18	0
Pamphlets and posters	10/18	8/18	0
Games/puzzles/activity books related to animals, animal health, zoonoses and food safety	11/18	6/18	1/18
TV/radio commercials	10/18	8/18	0

Comments:

- I would encourage holding such classes more often.
- It would be great for children to learn about disease from the labs and with the help of literature
- If the classes are held by a professional it is always more interesting for the students.
- In the case of games, puzzles and activity books, the material would be easier to understand.
- We would like to share our knowledge with our colleagues from other schools
- Such classes will help the students to improve their knowledge and improve their health (3)
- It is very important
- Besides TV programs, more knowledge can be gained by these methods
- All the above mentioned methods are good ways to teach the students

Figure 6.1: Administrative map of Armenia showing the location of Aragatsotn and Kotayk marzes.

[i] Excel, Microsoft Inc., Washington, USA

Chapter 7: Outbreak investigation: Nosocomial *salmonella* in a veterinary teaching hospital, disease investigation and prevention measures [1]

Introduction

This chapter explores an outbreak investigation in a veterinary teaching hospital. Acting as biosecurity officer before, during and after the outbreak, the author was involved in all aspects of the disease outbreak and investigation from initial discovery and environmental sampling, through discussing and applying infection control responses for disease control and prevention. This chapter focuses on problem identification but the incident itself encompassed needs assessment (provided through positive environmental and animal salmonella test results) and outreach (to students, staff, clients and the general public).

Routine environmental and animal testing for *salmonella* showed increased incidence of positive results of a single serogroup of *salmonella.* This discovery initiated investigation and outreach. Though not in the form of a questionnaire or survey, this routine passive monitoring for disease acted as a source of needs determination. Exploration of the problem is presented in detail in the paper that follows. What was not presented this paper is elaboration on the level and extent of outreach that was necessary to inform, educate, mobilize and allay the fears of students, staff, clients and the general public regarding this outbreak. Over the course of two months many meetings and conference calls were held with hospital faculty and staff, facilities management and biosecurity committee members to

[1] This paper is being submitted to JVIM. Authors: Kay K. Steneroden, David C. van Metre, Charlene Jackson and Paul Morley.

discuss the outbreak, and to plan and carry out mitigation efforts. Mass emails were used to inform veterinary teaching hospital staff and students of the status of the outbreak and mitigation efforts. Transparency was encouraged and large animal faculty, residents and staff was encouraged to communicate with clients about the outbreak and what the veterinary teaching hospital was doing to control the outbreak and prevent further spread.

While the paper's focus is on outbreak investigation, addressing this veterinary public health issue clearly encompassed a holistic approach including the fundamental components of determining need, problem investigation and outreach.

Detection and control of a nosocomial outbreak caused by *Salmonella* Newport at a large animal hospital

Nosocomial infections caused by *Salmonella enterica* are an important hazard for veterinary hospitals, especially large animal facilities. *Salmonella enterica* was the most common agent associated with outbreaks of nosocomial disease at veterinary teaching hospitals and was the most commonly cited reason for closure according to a recent survey.[1] Twenty of 38 responding veterinary teaching hospitals from throughout the world identified *Salmonella* as a cause of nosocomial outbreaks during the preceding 5 years. Additionally, while outbreaks are reportedly more common at large animal hospitals,[1-6] outbreaks have also occurred in small animal hospitals, and zoonotic infections are a common feature in both settings.[7-9] Risk factors associated with colonization and infection of large animals have been described.[10-13]

The documented risks associated with nosocomial *Salmonella enterica* infections have also prompted the initiation of control measures in many private and veterinary teaching hospitals.[1-4,10,11,14] These control measures have included establishment of comprehensive infection control protocols, environmental and patient surveillance, segregation of patients and equipment, appointment of individuals to conduct and oversee infection control activities, and development of training programs regarding infection control practices for personnel.[1,2,15-20] Despite aggressive control efforts, outbreaks of salmonellosis have frequently resulted in closure of veterinary teaching hospitals to stop nosocomial transmission and allow mitigation of environmental contamination through cleaning, disinfection, and remodeling of facilities. While this dramatic response has been seen as a necessary last resort that was required to protect patients and hospitals, it creates significant financial losses, limits provision of care for animals in need, and interrupts veterinary student education.

Additionally, while it is often assumed that outbreaks of salmonellosis occur because of intensive infection control practices and routine surveillance are lacking, there is little published evidence to support the related contention that such practices can successfully mitigate subsequent outbreaks. The purpose of this chapter is to describe how active patient and environmental surveillance and aggressive mitigation allowed control of an outbreak of nosocomial *S. Newport* infections in a large referral hospital without resorting to closure.

Materials and methods

Study Overview – An outbreak of *S. Newport* infections was detected among hospitalized large animal patients in August and September of 2006 at the John L. Voss Veterinary Teaching Hospital (JLV-VTH)using data obtained through ongoing, standardized surveillance techniques. Patient and environmental data were analyzed to identify temporal and spatial relationships related to the spread of a single *S.* Newport strain among patients and within the hospital environment. Data were also summarized relative to the timing of standardized and special mitigation efforts that were employed during the outbreak. The genetic relatedness of the *S.* Newport isolates obtained from patients and environmental samples was investigated using genetic analysis (pulsed-field gel electrophoresis) A description of the method is detailed below..

Patient Information – Medical records were reviewed of all large animal patients (including new world camelids, goats, cattle, pigs and horses) hospitalized at the JLV-VTH between July 28, 2006 (date of admission of the index case; Day 0 of the outbreak) and September 27, 2006 (date that the last environmental sample was obtained that cultured positive; Day 63 of the outbreak). Events in the outbreak were described as days elapsed since the admission of the first animal from which *S.* Newport was isolated. Data retrieved from the records included patient signalment, initial complaint, dates and locations where animals were housed in the JLV-VTH, paths of patient movement within the JLV-VTH for purposes of diagnostic or therapeutic procedures or for mitigation of infectious disease transmission, diagnostic and surgical procedures performed, dates of sampling and culture results

for fecal samples that were submitted for culture of *S. enterica*, clinical signs that may have resulted from *S. enterica* infections, clinical outcomes for patients (survived and were discharged vs. died or euthanized), and necropsy findings of animals that died or were euthanized.

Fecal samples - In accordance with the existing biosecurity protocols for the JLV-VTH,[21] fecal samples were obtained from all large animal inpatients at the time of admission and then twice per week (Tuesday and Friday) throughout hospitalization. On Day 18 of the outbreak, the frequency of regularly scheduled sampling was increased to three times per week (Monday, Wednesday, and Friday) while fecal sampling at admission continued.

Environmental Samples – In accordance with the existing biosecurity protocols for the JLV-VTH,[21] samples were routinely obtained from surfaces within the JLV-VTH environment to monitor potential contamination with *Salmonella*. Two different sampling techniques and sampling strategies were employed for this purpose. Environmental (ENV-H) samples obtained with electrostatic wipes[a] were collected monthly at 63 predetermined sites located throughout the small and large animal areas of the JLV-VTH. As previously described,[15] ENV-H samples were obtained by wiping a commercially available electrostatic cleaning wipe[a] across predetermined areas of floor and hand-contact surfaces (e.g. countertops, computer keyboards, telephones) within the JLV-VTH. Samples of hand-contact surfaces were obtained using a gloved hand, while samples of floor surfaces were obtained using the commercially available mops designed for use with the electrostatic wipes[b]. Surfaces of mops that contacted wipes were disinfected prior to collecting each

sample by spraying with 90% isopropyl alcohol which was allowed to dry. Sites sampled included primary traffic areas for personnel and patients, reception areas, treatment rooms, and personnel areas (including records rooms, teaching areas, staff offices, and locker rooms). Of 63 sites that were routinely sampled using the ENV-H methods, 16 were from areas in the agricultural animal ward, 26 were collected from the equine ward, 19 were collected from the small animal hospital and reception areas, and 2 were collected from the Colorado State University Veterinary Diagnostic Laboratory (CSU-VDL). A minimum of 12 hrs was allowed to elapse after cleaning and disinfection prior to obtaining ENV-H samples

Environmental samples were routinely obtained in large animal patient stalls (ENV-S) using commercially available sponges[b] pre-moistened with buffered saline after cleaning and disinfection, as previously described.[11] A minimum of 12 hrs was allowed to elapse after cleaning and disinfection prior to obtaining ENV-S samples. The ENV-S samples were collected by wiping sponges across the wall and floor surfaces of the interior of the stall, taking care to avoid sampling floor areas stepped upon by the individual performing the sampling. Once sampled, stalls were kept vacant until negative culture results for *S. enterica* were obtained. In the agricultural animal ward, time and space constraints necessitated that cattle stalls were sometimes used before ENV-S sample results were known. In these instances, cattle from the same herd-of-origin were sometimes placed into stalls before culture results were known; cattle from other herds-of-origin were never placed in a stall before negative *S. enterica* culture results were obtained.

Personnel collecting ENV-H and ENV-S samples wore clean latex examination gloves and clean rubber boots or clean rubber-soled work shoes. Gloves were changed prior to collecting each sample. Footwear was immersed in a footbath or footmat containing peroxymonosulfate disinfectant [c] prior to upon entry into areas in the large animal hospital.

Routine collection of ENV-H samples occurred as previously scheduled on Day 17 of the outbreak. Subsequently, as mitigation efforts proceeded, multiple sets of environmental samples were obtained from targeted areas of the JLV-VTH to aid in determining the extent of environmental contamination. ENV-H samples were also collected during the outbreak from additional locations (beyond the 63 sites routinely sampled) to provide additional data about the scope of contamination and the effectiveness of mitigation efforts. Additionally, environmental surveillance of stalls and anterooms within the Equine Isolation building are typically sampled using the ENV-S technique. However, after the onset of the outbreak, these areas were sampled using the ENV-H technique.

Culture of *Salmonella enterica* — All culture and susceptibility testing was performed at the CSU-VDL. Broth enrichment was used for all *Salmonella* cultures. Fecal samples (1 g) were placed in 10 mL of tetrathionate broth[d] with iodine and incubated at 42ºC for 18 hrs. ENV-S samples were placed in 10 ml of thioglycollate broth[e] and incubated at 35°C for 48 hrs. ENV-H samples were placed in 90 ml buffered peptone water[f] and incubated for 24 h at 35°C, a 1 ml sample was then passed into 9 ml of tetrathionate broth and incubated overnight at 42° C, and finally 0.1 ml of this broth culture was passed into 10 ml of Rappaport-Vassiliadis Broth [g]

and incubated overnight at 35° C. After final incubation, these enriched samples were streaked for isolation on XLT4 agar[h] and incubated at 37ºC for 24 to 48 hrs. Plates were evaluated after 24 and 48 hrs of incubation to identify colonies producing hydrogen sulfide which were considered to be suspect-positive for *S. enterica*. Suspect-positive isolates were plated on trypticase soy agar with 5% sheep red blood cells[i] and incubated at 37ºC for 16 hrs. Isolates were then evaluated with *Salmonella* poly-O antisera and group-specific antisera. Isolates that reacted with both poly-O and group specific antisera were assigned a presumptive identification of *Salmonella enterica.*

The earliest that fecal cultures could be interpreted as being suspect-positive was approximately 2 days after submission, and samples were never concluded to be culture-negative until at least 3 days after submission. The earliest that culture of ENV-H samples could be interpreted as being suspect-positive was 5 days after submission, and cultures were never concluded to be culture-negative until at least 7 days after submission. The earliest that culture of ENV-S samples could be interpreted as being suspect-positive was 3 days after submission, and cultures were never concluded to be culture-negative until at least 5 days after submission. All isolates were evaluated for antimicrobial susceptibility using agar diffusion methods as previously described.[22] These results were usually available within 2 days of presumptive identification of *S. enterica* isolates. All *S. enterica* isolates were sent to the United States Department of Agriculture-National Veterinary Services Laboratories, Ames, IA for serotyping. During the outbreak, because results of serotyping are often not available for a month or longer after submission,

Salmonella enterica isolates were assumed to spread through clonal dissemination if they had the same serogroup and antimicrobial susceptibility pattern. After serotyping, isolates determined to be *S.* Newport that had the same antimicrobial susceptibility pattern were designated as the "Outbreak Strain."

Pulsed-field gel electrophoresis — In order to investigate the genetic relatedness of *S.* Newport isolates, isolates collected during the outbreak were sent to the USDA-ARS Bacterial Epidemiology and Antimicrobial Resistance Research Unit for analysis of genetic similarity using results of pulsed-field gel electrophoresis. Representative isolates included in this comparison were purposefully selected from each of the patients found to be shedding the Outbreak Strain, as well as 4 isolates recovered from environmental sampling sites distributed throughout the facility. Additionally, *S.* Newport isolates recovered from samples submitted to the Colorado State University Veterinary Diagnostic Laboratory (CSU-VDL) from locations in Colorado (not the JLV-VTH) were compared to isolates recovered during the outbreak. Specifically, 1 *S.* Newport isolate was purposefully selected from an equine, bovine, and canine patient if it was the isolate most recently recovered from that species prior to the onset of the outbreak.

The 24-hour *Salmonella enterica* PFGE procedure was performed as described by the National Molecular Subtyping Network for Food borne Disease Surveillance (Pulse Net).[23] Briefly, whole-cell DNA plugs embedded in 1.0% agarose [j] were digested with 10 U of the selected restriction enzyme (*XbaI*)[k] The DNA standard was prepared from *S.* Newport AM01144 and digested DNA was separated by use of a PFGE system as per manufacturer's instructions. [l] Electrophoresis was

carried out for 19 hrs at 6 V using 2.2 L of a buffer [m] at a temperature of 14ºC and an initial pulse time of 2.16 seconds followed by a final switch time of 63.8 seconds. Genetic analysis software [n] was used to normalize the band patterns for comparison with PFGE profiles.

Biosecurity Standard Operating Procedures at the JLV-VTH – Infection control and biosecurity policies and procedures were available online to all personnel,[21] and all students, staff and house officers received formal orientation prior to working with patients. It was a stated expectation that all personnel working in the JLV-VTH complied with all aspects of these policies and procedures.

All cattle, goats, new world camelid and pig inpatients were housed in the agricultural animal ward (Figure 1). All inpatients in the agricultural animal ward were housed in an individual stall that had solid side walls, and slatted metal gates in the front and rear of the stall. When dams were admitted with their offspring, they were housed together in the same stall. A footbath containing a peroxymonosulfate disinfectant was placed at the entry gate to each stall and at the entry and exit points of the agricultural animal ward. All personnel wore clean coveralls and rubber overboots while handling animals. Disposable, single-use thermometers [p] were used on all inpatients. Animals housed in the agricultural animal ward that were known or suspected to be shedding *S. enterica* were maintained in this ward with increased biosecurity precautions. These precautions included cordoning off of the animal's stall, alteration of treatment and evaluation schedules to reduce frequency of animal contact with personnel, mandatory wearing of disposable barrier nursing gowns and disposable exam gloves by all

personnel when working with the animal, use of a hospital-owned stethoscope that was assigned to each animal, and mandatory use of hand hygiene practices immediately after contact (hand-washing with bactericidal soap or use of hand sanitizer

Horse inpatients known or suspected of shedding *S. enterica* or other contagious agents were managed in the equine isolation building. Horse inpatients admitted for other gastrointestinal conditions were housed in the equine colic ward. Other equine inpatients were housed in the general equine inpatient areas, but were segregated by service (e.g., medicine, surgery). All inpatients in the equine ward were housed in individual stalls with solid side and rear walls and a slatted entry gate. Mares admitted with their foals were housed together in the same stall. A new electronic thermometer was assigned to each inpatient in the equine ward upon admission. Footmats [q] containing a peroxymonosulfate disinfectant were placed at the entry and exit points for the aisles leading to different sections of the equine ward, and at the gate for all colic recovery stalls and at the entry of all isolation stalls. Personnel caring for horses in the main inpatient sections wore clean smocks and work shoes without overboots. Personnel caring for horses in the colic recovery aisle wore clean, knee-length laboratory coats dedicated for use in this area, plastic barrier gowns dedicated for use with a specific patient were worn over the laboratory coats, in addition to disposable exam gloves, and rubber overboots dedicated for use in the colic ward. Personnel working in equine isolation wore scrubs used only in this area over their clothes, disposable barrier gowns assigned for use with a specific patient, disposable exam gloves, bouffant caps, and rubber

overboots dedicated for use in this area. Mandatory hand hygiene practices, identical to those employed for high-risk animals in the animal agriculture ward, were practiced after each animal was handled.

Because dairy cattle inpatients admitted to the JLV-VTH were known to have greater risk of shedding *Salmonella* compared to the equine inpatients,[24] cleaning personnel moved from the relatively lower-risk equine inpatient areas to the agricultural animal ward as they conducted their cleaning tasks. Other personnel were not allowed to work in both areas on the same day except in case of an emergency. Personnel who cleaned the higher-risk equine areas (colic recovery aisle and isolation facility) did so at the end of their shift, and did not enter the agricultural animal ward during that work shift. All cleaning personnel wore hospital-dedicated outerwear, disposable examination gloves, and rubber overboots. Separate, covered disposal bins for waste and soiled bedding were used for the agricultural animal ward, equine colic recovery aisle, other equine inpatient areas, and the equine isolation facility. Cleaning implements were shared among patients in the equine surgery and equine medicine aisles. Cleaning implements had shared use among stalls in the agricultural animal ward, with each implement being immersed in a peroxymonosulfate disinfectant before being used in another stall. Separate cleaning implements were assigned to each individual stall in the colic recovery aisle and the equine isolation facility.

Twice per day, soiled bedding was removed and replaced with fresh bedding in all occupied stalls, and all floor surfaces of the common areas of the entire facility were swept clean, rinsed with water, and sprayed with appropriately diluted

quaternary ammonium disinfectant solution.[r] Hand-contact surfaces in the large animal hospital were wiped with appropriately diluted quaternary ammonium disinfectant daily. Immediately after use, cattle chutes, wash areas, and equine stocks and the surrounding floors were scrubbed with anionic detergent, rinsed, and sprayed with appropriately diluted quaternary ammonium disinfectant.

Lead ropes, halters, brushes, and hoof picks were assigned for use with individual patients during its hospitalization, and were disinfected before use with other patients by cleaning with soap, then soaking for a minimum of 24 hrs in 0.05% chlorhexidine solution. Mouth gags, stomach tubes, and buckets were also assigned for use with individual patients during their hospitalization, and were cleaned with soap and water and sterilized using gas plasma or steam autoclaving between patients.

When stalls in the general inpatient areas of the equine ward were vacated, the general cleaning process included removal of bedding, rinsing of all surfaces with water, and scrubbing of all surfaces with detergent. Next, the entire stall and adjacent aisle-way were cleaned with a high temperature, high pressure water sprayer, then an appropriately diluted quaternary ammonium disinfectant was sprayed onto surfaces and allowed to dry. In the agricultural animal ward, equine colic aisle, and equine isolation ward, after removal of bedding, all surfaces were scrubbed with an anionic detergent and a dilute (1:12) bleach solution, thoroughly rinsed, and appropriately diluted quaternary ammonium disinfectant was sprayed onto all of the cleaned surfaces and allowed to dry. If *S. enterica* was recovered from an ENV-S sample, the stall was scrubbed with detergent and bleach solution and the

disinfectant application was repeated. If *Salmonella* was recovered from ENV-H samples, the location was scrubbed and cleaned with appropriately diluted quaternary ammonium disinfectant. Sampling and disinfection were continued until *Salmonella* was no longer recovered on culture of ENV-S or ENV-H samples.

Results

***Salmonella enterica* Shedding and Environmental Contamination at the JLV-VTH Prior to the Outbreak** -- Prior to this outbreak, despite ongoing active surveillance and the detection of other serotypes, *S.* Newport had not been recovered from a JLV-VTH patient since December, 2004, and had not been recovered from an ENV-H sample since June, 2005 (Table 1). In the 3 months prior to August, 2006, total of 296 large animal inpatients were screened to detect *S. enterica* shedding. Only 1.4% (4/296), of these patients was found to be shedding *S. enterica*: 2 cows (both shed serotype Cerro), 1 horse (serotype Give), and 1 pig (isolate was non-viable after shipping to NVSL). *Salmonella enterica* was only recovered from 1.6% (3/189) of ENV-H samples collected in the 3 months preceding August, 2006 (0 of 63 in May, 1 of 63 in June, and 2 of 63 in July). One of these isolates was serotype Montevideo, and the other 2 were serogroup E but were non-viable after shipment to NVSL.

Outbreak Strain – *Salmonella enterica* isolates recovered from the initial case and all other isolates thought to be associated with this outbreak were determined to be serotype Newport (serogroup C2), and all had identical antimicrobial susceptibility patterns. Isolates were resistant to amoxicillin-clavulanate, ampicillin, ceftiofur, cephalothin, chloramphenicol, streptomycin,

sulfonamide, and tetracycline and were susceptible to amikacin, gentamicin, enrofloxacin, and trimethoprim-sulfamethoxazole. Of the 499 *S. enterica* isolates recovered from active surveillance of JLV-VTH patients and environment between July 2002 and Aug 1, 2006, 148 (29.7%) were serotype Newport. Among these Newport isolates, 88% (131/148) had an antimicrobial susceptibility pattern identical to the Outbreak Strain. Only 11 other *S. enterica* of other serotypes were recovered during the same period and had susceptibility patterns matching other isolates (not the Outbreak Strain) recovered in the same period.. Because of requisite delays in obtaining serotype classification from USDA-NVSL, it could not be definitively confirmed that these were all the same serotype until after the end of the outbreak. Similarly, PFGE results could not be obtained until after shedding among patients had concluded.

Outbreak Summary – Through the course of this outbreak, a total of 8 patients admitted to the JLV-VTH were found to be shedding the strain of *S.* Newport that was associated with this outbreak (4 alpacas, 2 horses, 1 goat, and 1 cow). No *S. enterica* infections were identified among hospital personnel or clients during or subsequent to this outbreak. Intensive surveillance was employed throughout the outbreak in an attempt to identify all infected animals as soon as possible and also to identify all areas contaminated with *S. enterica*. The 1st culture-positive fecal sample was collected from the Index Case on August 8, 2006, and the last positive sample was collected from the last affected animal on September 1, 2006. Among all 34 fecal samples collected from the infected patients during the outbreak period, 42% (14/34) were positive for *S.* Newport. Additionally, after detection of fecal

shedding in the Index Case, the Outbreak Strain was recovered from 52 ENV-H samples obtained from widely distributed locations in the VTH (Figure 1). Environmental contamination was first detected on August 14, and additional follow-up samples were culture-positive throughout the outbreak until September 29 (28 days after the last culture-positive fecal sample was collected).

Shedding of *S. enterica* that was unrelated to the outbreak strain was common during the outbreak, which complicated interpretation of surveillance data. During the period when patients were found to be shedding *S.* Newport (August 8 – September 1; Days 11-35), a total of 220 fecal samples were collected from 145 large animal patients and screened for the presence of *S. enterica*. *Salmonella enterica* was isolated from fecal samples of 17 of 145 (11.7%) of these inpatients but only 8 (5.5%) were subsequently determined to be shedding the Outbreak Strain; the remaining 9 (6.2%) shedding other *S. enterica* serotypes. Similarly, a total of 29 fecal samples collected during this period (29/220; 13.2%) were culture-positive for *S. enterica*, but only 16 of these isolates were later identified as the Outbreak Strain.

During the entire period of shedding and environmental contamination with the outbreak strain (August 1 - September 29, Days 11-63), a total of 427 fecal samples were collected from 234 patients to screen for *S. enterica* shedding (Table 1). Of these, 13.2% (31/234) of patients and 10.8% (46/427) of fecal samples were culture-positive (including the 8 patients which shed the Outbreak Strain). Nine other serotypes of *S. enterica* (Schwarzengrund, Typhimurium, Infantis, Mbandaka, Montevideo, Oranienburg, Meleagridis, Muenster, and Cerro) were recovered from

the 23 patients that shed *S. enterica* unrelated to the Outbreak Strain (19 cattle, 3 horses, and 1 pig). In addition to environmental contamination with *S.* Newport, other strains of *S. enterica* were cultured from 34 ENV-H samples collected before October 9 (serotypes Meleagridis, Typhimurium, Mbandaka, Montevideo, Give, and Putten).

Serotype information was not available for any of these isolates until after the outbreak, but isolates that were not serogroup C2 were assumed to be different from the Outbreak Strain based upon serogroup characterization. While more than one dairy cow from the same herd were sometimes found to be shedding the same type of *S. enterica*, nosocomial transmission of *S. enterica* other than the Outbreak Strain (*S.* Newport) was considered unlikely based upon epidemiological evaluation of temporal and spatial characteristics of surveillance data.

Index Case – The first isolate of the Outbreak Strain was cultured from a fecal sample obtained from a 2-year-old female alpaca (Alpaca A, Figure 2) as part of routine hospital surveillance. This animal was admitted to the agricultural animal ward on July 28, 2006 (Day 0 of the outbreak) for evaluation of abdominal pain and persistent recumbency. It developed generalized ileus on Day 4, and an exploratory laparotomy was performed under regional anesthesia to rule-out intestinal obstruction. Subsequently, a fistula was placed into the 1st stomach compartment to relieve progressive distention. Despite previous gastrointestinal disease, Alpaca A did not develop abnormally soft feces until Day 14. Fecal samples obtained on Days 1 and 3 were culture-negative for *Salmonella*, but the Outbreak Strain was recovered from fecal samples collected on Days 11 (August 8), 14, and 18. Results

from the 1st positive culture did not become available until Day 14 (August 14). This patient was discharged on Day 19 and the other positive culture results did not become available until after discharge.

Subsequent Cases - Eight days after admission of Alpaca A, an 8 year-old female alpaca (Alpaca B) was admitted to the agricultural animal ward for evaluation of chronic weight loss which was subsequently determined to be caused by fungal pneumonia. This animal originated from a different farm than Alpaca A. The Outbreak Strain was recovered from fecal sample obtained from Alpaca B on Day 14 despite having formed feces (Figure 2). A previous sample obtained on Day 11 was culture-negative and this patient did not show signs of GI illness until Day 16. On Day 12, a 9 day-old alpaca cria and its 3 year-old dam (Alpacas C and D, respectively, which also originated from a different farm) were admitted because the cria showed signs of constipation, weakness, and generalized paresis. Fecal samples collected from both animals on Day 14 were culture negative and dam was culture negative on Day 18, but the Outbreak Strain was isolated from samples collected on from the cria on Day 18 and from the dam on Day 21 (Figure 2). The cria developed diarrhea that was attributed to the *Salmonella* infection, but the dam remained clinically normal throughout hospitalization.

A 10 year old Quarter Horse (Horse A) was admitted for evaluation of lameness on Day 0, and samples collected on Days 4 and 7 were culture-negative. After initial evaluations, this horse was discharged on Day 10 and readmitted on Day 18 for arthroscopic surgery. A fecal sample collected on Day 18 was culture-negative, but the horse became febrile and neutropenic on Day 20. The Outbreak

Strain was recovered from a fecal sample collected on that day and was moved to isolation when results were received on Day 22. This horse developed severe enterocolitis, diarrhea, and septicemia and died on Day 25. At necropsy, severe necrotizing, suppurative typhlocolitis was evident, and the Outbreak Strain was recovered from cultures of small intestine, liver, lung, and spleen.

On Days 21 and 25 the Outbreak Strain was recovered from an adult goat and an adult cow (Goat A and Cow A, respectively), that were housed in the agricultural animal ward. The Outbreak Strain was recovered from samples collected on their first day of hospitalization. Additionally, the Outbreak Strain was recovered from a fecal sample collected on Day 33, from an adult horse (Horse B). Horse B was admitted on Day 24 for orthopedic surgery, and 3 fecal samples were culture-negative prior to detecting *Salmonella* shedding on Day 33. Horse B was that last patient identified as shedding the Outbreak Strain, which was recovered from a fecal sample obtained on Day 36.

Environmental Contamination with *S. enterica* -- Between Day 17, the first day that environmental samples were obtained after the onset of the outbreak, and Day 63, when environmental contamination with the Outbreak Strain was last detected in the hospital environment, a total of 295 ENV-H and 32 ENV-S samples were cultured to detect *S. enterica* contamination (Tables 1-2). Overall, the Outbreak Strain was isolated from 14.2% (42/295) of ENV-H samples and other unrelated strains of *S. enterica* were isolated from 7.5% (22/295; Table 1). Multiple strains were not detected in any of these samples. The Outbreak Strain was most commonly recovered from areas where infected animals were housed (agricultural

animal ward and equine isolation), but was also recovered from other widely dispersed areas throughout the facility (equine ward and other areas of the JLV-VTH, Table 1 and Figure 1).

Among EHV-H samples obtained during the outbreak, 56.3% (166/295) were obtained from floor surfaces within the JLV-VTH, 18.3% (55/295) from hand-contact surfaces, and 22.0% (65/295) were composite samples of both hand-contact and floor surfaces; 3.1% (9/295) of ENV-H samples were obtained of other types of surfaces during the outbreak (rubber boots, parking lot, etc). Overall, 14.5% (8/56) of ENV-H samples of hand-contact surfaces were contaminated with *S. enterica*, compared to 22.9% (38/166) of samples from floor surfaces, and 24.6% (16/65) of composite samples from hand-contact and floor surfaces.

Among the ENV-S samples obtained during the outbreak, 1 of 32 (3.1%) was culture positive for the Outbreak Strain, and 3 of 32 (9.4%) were positive for unrelated strains of *S. enterica*. The Outbreak Strain was also recovered from anterooms and stalls in Equine Isolation, but these were sampled using the ENV-H technique during the outbreak. Among all environmental samples obtained from the Equine Isolation facility during this outbreak, 33.3% (11/33) were culture-positive for the outbreak strain; other strains of *S. enterica* were not recovered from this facility during the outbreak. All of these isolates were recovered from stall or anteroom surfaces, none from the office.

Control Measures - Laboratory results indicating that patients were shedding the Outbreak Strain became available for the first 3 affected patients on Days 14, 17, and 20, respectively. In accordance with standard biosecurity

operating procedures [21], increased precautions were automatically initiated in the agricultural animal ward when results indicated that a patient was shedding *S. enterica*. Considering that these patients did not have known epidemiological ties prior to admission, and considering the similarity of the *S. enterica* isolates, it was strongly suspected that these infections had resulted from nosocomial transmission as soon as data regarding serogroup and antimicrobial susceptibility became available.

After recovery of the Outbreak Strain from the first 2 patients, supervisors in the large animal hospital (clinical, nursing, and cleaning) were contacted and asked to reinforce that extra vigilance was needed among personnel regarding hygiene and biosecurity precautions. This would be a typical reaction whenever nosocomial infection was suspected, but information regarding the phenotypic characteristics of these isolates (*S. enterica* that was multidrug resistant and serogroup C2) increased the possibility that this strain could be similar to *S.* Newport strains that had caused several serious outbreaks in veterinary hospitals and other animal populations in the U.S.[s,25,26] As such, biosecurity and hygiene precautions were increased after results became available on Day 17 indicating that the Outbreak Strain had been recovered from a second patient. Specifically, personnel working in the agricultural animal ward were required to use disposable exam gloves when handling any patient (discarding after each patient), and cloth coveralls were assigned for dedicated use with each inpatient (stored stall-side). Additionally, nursing staff and students removed materials, and thoroughly cleaned and disinfected surfaces in

personnel areas (records room, offices, etc) in the agricultural animal ward (Figure 1) using appropriately diluted quaternary ammonium disinfectant.

Additional precautions were initiated On Day 20 after results became available regarding the third affected patient (Alpaca C). All inpatients in the agricultural animal ward were discharged except for Alpacas B, C, and D which were moved to the Equine Isolation building and managed using isolation protocols that were standard for that facility. New admissions to the agricultural animal ward were voluntarily limited to emergency situations when it was concluded that patients could only be managed in a referral hospital such as the JLV-VTH (not in the field). Otherwise, patients typically admitted to the agricultural animal ward were cared for in the field by ambulatory clinicians from the JLV-VTH. Clients were informed of the reason for these precautions (i.e., the potential nosocomial *Salmonella* transmission) whenever they called to schedule inpatient services. Plans for enhanced cleaning and disinfection were also initiated. All stalls and aisles in the agricultural animal ward (Figure 1) were scheduled to be cleaned at least twice prior to mist application of peroxymonosulfate disinfectant solution (4 times normal strength) on Day 24 as previously described.[18] All personnel working in the large animal wards of the JLV-VTH were provided detailed information about affected patients such as culture results, clinical history, clinical condition, housing and previous movement within the JLV-VTH, biosecurity precautions, and plans for further actions such as intensive cleaning. Faculty and staff working in the large animal wards of the JLV-VTH were also provided detailed updates approximately every other work day throughout the outbreak. Less detailed communications were

periodically sent to all students, faculty, and staff working in the JLV-VTH to increase overall awareness and elicit careful adherence to hygiene and biosecurity precautions.

On Day 21 (Friday, August 18), preliminary culture results from ENV-H samples collected on Day 17 became available, indicating that 14 of 63 (25.2%) environmental surveillance samples were culture-positive for the Outbreak Strain, and unrelated strains of *S. enterica* were recovered from an 3 other samples. The Outbreak Strain was recovered primarily from the agricultural animal ward (10 sites, Figure 1), but also from floor surfaces in the CSU-VDL (2 sites) and from the small animal hospital (2 sites). While additional cleaning and disinfection was already underway within the agricultural animal ward, plans were revised to further intensify hygiene and biosecurity efforts in all areas of the large animal wards. Patient surveillance was also intensified: beginning on Day 21, samples were collected from all large animal patients at the time of admission and every Monday, Wednesday and Friday through the remainder of the outbreak.

Despite implementation of intensive control measures, on Day 24, results of fecal samples obtained on Day 21 indicated that 2 additional patients were shedding the Outbreak Strain, including Horse A, the first infected patient housed outside of the agricultural animal ward. In response, a full set of 63 ENV-H samples was collected on Days 24 and 25 to evaluate the effectiveness of decontamination of areas that had been cleaned and disinfected and to determine if contamination had spread to other areas in the JLV-VTH. Additionally, biosecurity precautions were increased throughout the equine general inpatient area of the JLV-VTH. Specifically,

rubber overboots were required to be worn by all personnel when working in this area and footbaths containing normal strength (1%) peroxymonosulfate were placed in front of each stall that housed an animal. In addition, personnel contact with patients was limited whenever possible, the need for excellent hand hygiene was emphasized to all personnel, movement of patients within the hospital was restricted to that which was absolutely necessary (e.g., walking of large animal inpatients for therapy or exercise was discontinued). While movement of personnel between the agricultural animal ward and the equine wards was always strongly discouraged, in light of ongoing events, movement between these wards was strictly forbidden. Discharge of animals colonized with *S. enterica* was considered a priority, when their medical conditions allowed, in order to reduce the potential for further exposing patients or personnel in the JLV-VTH. By Day 26, no patients known to be shedding the Outbreak Strain remained in the hospital. All owners were alerted to the shedding status of their animals prior to discharge and were counseled in depth about precautions that needed to be taken to minimize the likelihood of transmission of *S. enterica* to people or other animals at their home premises.

On Days 28 and 29, culture results became available for ENV-H samples collected on Days 24 and 25. Despite the significant mitigation efforts that had been initiated, these results indicated that environmental contamination was still widely distributed in the large animal hospital: 13 of 63 (20.1%) ENV-H surveillance samples were culture-positive for the Outbreak Strain and additional strains of S. enterica were recovered from 4 other samples. The Outbreak Strain was again

primarily recovered from the agricultural animal ward (9 sites), but also from surfaces in equine inpatient areas (3 sites) and from the equine isolation building (1 site; Figure 1). All personnel working in the hospital were apprised of these results, and they were asked to ensure that they and others were carefully adhering to all hygiene and biosecurity precautions. Based upon these results, admissions of equine patients for elective procedures were rescheduled whenever possible, and plans were developed to repeat the cleaning and disinfection of areas where contamination had been detected. Again, clients were informed of the reason for these precautions (i.e., the potential nosocomial *Salmonella* transmission) whenever they called to schedule inpatient services. Surfaces were scrubbed with detergent and bleach, rinsed and disinfected with appropriately diluted quaternary ammonium solution. Afterwards, on Day 32, a 4 times regular strength solution of peroxymonosulfate disinfectant was applied as a mist[18] in the breezeway, and all areas in the agricultural animal ward. Areas that contained sensitive equipment (computers, audiovisual equipment, microscopes, etc) were scrubbed with detergent and disinfected by hand using appropriately diluted quaternary ammonium disinfectant. Plans were also made to intensively clean and disinfect all inpatient areas of the equine ward in a 2 phase effort. To enable the first phase, the few equine inpatients remaining in the south end of the equine inpatient area were moved to stalls in the north west area of the equine inpatient ward. After scrubbing surfaces with detergent and bleach, rinsing, and disinfection with appropriately diluted quaternary ammonium disinfectant, these areas were again disinfected on

Day 35 by mist application of 4 times regular strength peroxymonosulfate disinfectant solution.

A revised set of 51 ENV-H samples was collected on Day 33, and results that became available on Day 38 indicated that 7 of 51 (13.7%) of cultures yielded the Outbreak Strain (3 from equine isolation facilities, 2 from the north end of the equine inpatient facilities, and 2 from the agricultural animal ward), while 2 others yielded other strains of *S. enterica*. Additionally, results became available on Day 35 indicating that Horse B was shedding the Outbreak Strain; this horse was immediately moved to the equine isolation facility. These were results were extremely disconcerting considering that all animals known to be shedding *S. enterica* had been previously discharged, negative fecal cultures had been obtained from all remaining patients, and extremely rigorous cleaning and control efforts had been initiated. Further, similar control methods had been successfully employed on other occasions prior to this outbreak to alleviate environmental contamination and contain the threat of nosocomial transmission.

This fecal sample obtained from Horse B on Day 35 was the last culture yielding the Outbreak Strain. It remained in isolation until negative results were obtained from a series of 5 fecal cultures obtained on Days 37 through 41, after which it was discharged. Equine patients remaining in the hospital were moved to the south end of the equine general inpatient ward on Day 37 (Figure 2); equine colic patients were segregated from other patients, and standard operating procedures were maintained. All surfaces in the north end of the equine general inpatient areas, as well as areas in the equine isolation facility and the agricultural

animal ward that were found to be culture-positive were intensively scrubbed with detergent and bleach, rinsed and disinfected with appropriately diluted quaternary ammonium solutions. Subsequently, on Day 40, the northern half of the equine inpatient facilities, the agricultural animal ward, and the equine isolation facilities were disinfected by mist application of 4 times regular strength peroxymonosulfate disinfectant solution.

A revised set of 53 ENV-H samples was collected on Day 41, and results became available on Day 45 indicating that 1 sample (1.9%) collected in the equine isolation facility yielded the Outbreak Strain, while other strains of *S. enterica* were recovered from samples collected in the agricultural animal ward. Areas in the equine isolation facility again were intensively cleaned and disinfected using standard cleaning procedures, and on Day 47 were disinfected once again using mist application of 4 times regular strength peroxymonosulfate disinfectant. On Day 52, another revised set of 49 samples was collected, and results became available on Day 56 indicating that 1 sample (2.0%) collected in the same area of equine isolation facility yielded the Outbreak Strain. This stall and anteroom was cleaned and disinfected again using standard cleaning procedures, as well as mist disinfection, but was culture-positive again on samples collected on Day 63. Cleaning, standard disinfection, and mist disinfection were repeated in this isolation stall and subsequent culture results were negative.

Follow-up – Subsequent to the last recovery of the Outbreak Strain on Day 63, *S.* Newport was not recovered from patients or environmental samples for several months despite active surveillance showed (Table 1) *Salmonella* Newport

was not recovered again from a large animal patient until December 19, 2006, and this *S.* Newport was not recovered from an environmental sample until July 24, 2007. Other serotypes of *S. enterica* recovered from patients during this subsequent period included Give, Havana, Infantis, Mbandaka, Meleagridis, Montevideo, Muenster, Oranienburg, Schwarzengrund, and Typhimurium.

Genetic comparisons of isolates – On Day 32, representative *S. enterica* isolates that had been recovered during the outbreak were sent to the USDA-ARS Bacterial Epidemiology and Antimicrobial Resistance Research Unit for genetic comparison. Results of these analyses became available on Day 46, indicating that isolates previously suspected of being spread through nosocomial dissemination were indeed indistinguishable based upon analysis of PFGE results (Figure 2). In contrast, outside isolates that were analyzed for comparison purposes were distinguishable from the Outbreak Strain, but the genetic fingerprints showed varying degrees of similarity. The outside isolates that had the same antimicrobial susceptibility pattern as the Outbreak Strain (isolates O and P) had greater similarity (97% and 95% similarity with the Outbreak Strain, respectively) than did the isolate that had a very different susceptibility pattern (isolate Q) which showed only 77% homology. In comparison to genetic patterns in the USDA's VetNet database which contains PFGE typing results for 1,270 *S.* Newport isolates from throughout the U.S., isolates with genotypes identical to the Outbreak Strain (pattern JJPX01.0170) represent only 1.5% of *S.* Newport isolates. In contrast, isolate P was representative of the most common genotype in the VetNet database (pattern JJPX01.0023, 16.3% of S. Newport isolates), while the genotype for isolate

O (pattern JJPX01.0048) represented 2.5% of *S.* Newport isolates and the genotype for isolate Q (pattern JJPX01.0338) represented 0.08% of *S.* Newport isolates in the VetNet database.

Discussion

During this outbreak of nosocomial *S. enterica* infections, the Outbreak Strain was spread extensively throughout our hospital and appeared to persist in the environment in spite of aggressive control measures, including rigorous cleaning and disinfection. Contagiousness of the isolate, widespread environmental contamination, and environmental persistence are common features among major *S. enterica* outbreaks that have previously forced closure of large referral hospitals, including the JLV-VTH at CSU.[2-4 s] As such, we believe that closure of our hospital was an imminent threat that was avoided primarily because of aggressive surveillance and mitigation strategies, albeit with difficulty. Assuming that the outbreak was initiated by shedding and contamination from the index case, 7 patients developed nosocomial infections as a result of this outbreak, 3 of which were clinically affected and 1 of which died. While these were very serious untoward consequences, we strongly believe that *S. enterica* spread among patients and in the hospital environment could easily have been much worse were it not for the aggressive surveillance and mitigation efforts that were employed.

It seems inevitable that *S. enterica* would have spread undetected to other patients if we had not been using active *S. enterica* surveillance in all hospitalized large animal patients. Of the 8 patients found to be shedding the Outbreak Strain, only 3 developed clinical disease that was attributed to *S. enterica* infections.

Alpacas B and C both developed diarrhea 6 days after admission, but neither developed other signs such as fever or leukopenia. Horse A, admitted for lameness subsequently developed fever, neutropenia on day 20 and subsequently died after developing enterocolitis, diarrhea, and septicemia. Both alpacas survived until discharge. Therefore, had it been our practice to only sample animals with clinical signs compatible with salmonellosis (e.g., diarrhea, fever, leukopenia), only 3 of 8 animals known to be infected would have been detected. Notably, *Salmonella* infection of the index case would not have been detected or at least detection would have been significantly delayed. Failing to detect *S. enterica* shedding in these subclinically infected animals likely would have resulted in even greater environmental contamination of the hospital and spread to more animals. Additionally, because we had personnel specifically assigned to monitor nosocomial disease threats to the hospital, because we had established protocols for managing infected animals and decontaminating the hospital environment, and because our personnel were experienced in carrying out these protective actions, we were able to respond quickly and aggressively to this threat.

The most probable source for initial dissemination of the Outbreak Strain was the Index Case (Alpaca A). Given the extent of contamination that was subsequently detected, it is likely that large numbers of bacteria were shed by this animal, and contamination was spread in the agricultural animal ward by personnel carrying out their required duties and also through movement of the patient. This patient was walked repeatedly in and around the agricultural animal ward in an attempt to promote resumption of normal GI motility before *S. enterica* shedding

was detected. Walking this patient outside of that ward could have facilitated spread of contamination to other areas of the facility via foot traffic and movement of other patients. The earliest indication of potential nosocomial transmission of the Outbreak Strain did not occur until 18 days after admission of the Index Case when culture results became available showing that other patents were shedding *S. enterica* with the same phenotype. Concern regarding the potential for a nosocomial outbreak was heightened 3 days later when results of environmental surveillance indicated widespread contamination of the Outbreak Strain in the hospital environment (14/63 ENV-H samples). Integration of patient and environmental culture data across time and location enabled us to better define the scope of the outbreak and initiate targeted cleaning and disinfection measures, as well initiate more rigorous patient handling protocols.

As demonstrated in this outbreak, it is critical to differentiate strains of *S. enterica* in order to identify dissemination of a single *S. enterica* clone within a population that is comprised of animals from multiple sources. Unfortunately, the requisite lag time associated with obtaining culture results and phenotypic information (serogroup and antibiogram) significantly complicates management of risks associated with spread of *S. enterica* in a veterinary hospital. Two to 5 days was required after sample submission to obtain culture results and serogroup information, and an additional 1-3 days was needed to obtain antimicrobial susceptibility profiles. To further complicate matters, differentiation of strains from the same serogroup using antibiograms is tentative at best, but it often requires a month or longer to obtain more definitive serotype information from the USDA

reference laboratory. While, PFGE can also be used to determine the genetic relatedness of multiple isolates, this type of analysis is expensive and is not widely available, as was the situation for the CSU-VDL during this outbreak. Polymerase chain reaction (PCR) is sometimes used to analyze fecal samples and environmental samples to identify *S. enterica*. However, results of this assay provide only dichotomous yes or no answers, not other phenotype or genotype characterization that is required to identify clonal dissemination. Additionally, positive PCR results could theoretically be obtained when samples are contaminated with dead organisms or even DNA fragments. This may be particularly troublesome when analyzing environmental samples collected as follow-up to decontamination measures.

The need to differentiate among strains of *S. enterica* in this type of animal population is illustrated well by surveillance data obtained during the outbreak. While cultures of 14.7% [43/292] of environmental samples yielded the Outbreak Strain, unrelated *S. enterica* strains were recovered from an additional 8.2% (24/292) of samples. Clearly best practices dictate that these areas contaminated with other strains of *S. enterica* needed to be disinfected, but the implications related to ongoing contamination with the Outbreak Strain were clearly different. The proportion of fecal cultures that yielded unrelated strains was even more pronounced; 4.2% (18/427) of fecal cultures yielded the Outbreak Strain while 6.7% (29/427) of fecal cultures yielded unrelated strains (Table 1). Again, best management practices were not different for patients that were found to be shedding unrelated *S. enterica* strains, but the implications and the responses are

substantially different than when infections were thought to have resulted from nosocomial transmission.

We believe that prompt reaction to this threat was aided by designation of personnel that had specific responsibility for ongoing analysis of surveillance data. In the JLV-VTH biosecurity program, the Director of Biosecurity along with a house officer are assigned responsibility for directing efforts designed to prevent and mitigate against nosocomial transmission of contagious disease agents, and to provide ongoing communication to hospital and other university personnel, referring veterinarians, and clients regarding the status of any known problems. We believe that this structure facilitates effective, rapid decision-making during an outbreak. It also helps to ensure that communication and transparency are effectively maintained, which is especially important to clients and referring veterinarians when patients are discharged from the hospital.

Despite the significance of this outbreak, the large animal hospital was able to remain open, although measures were taken to reduce admissions through provision of ambulatory service care and rescheduling of elective procedures. In contrast, during the outbreak which occurred at the JLV-VTH in 1996, 56 animals were infected, 3 deaths occurred and the hospital was closed for a 3 month period.[2] In 2001, a similar number of animals were infected (7) and died (1), but the hospital was closed for a one month period to facilitate extensive decontamination efforts[18] While closure might have been considered a more conservative and therefore more appropriate response to this outbreak, the benefits of such a closure must be measured against the adverse impacts on the health of animals denied admission,

the financial status and reputation of the hospital, and veterinary student education. Two factors were considered pivotal at the time that this decision was considered during the outbreak. First, despite inherent delays associated with cultures, results of our ongoing surveillance led us to conclude that we had detected clonal dissemination of *S. enterica* in patients and the environment soon after it had initiated. Second, in the intervening time since our previous challenge of this magnitude and the resulting hospital closure, we had identified methods allowing rapid, wide-scale environmental decontamination of facilities that can sometimes be employed without completely closing the facility.

Despite the expense of repeated environmental and patient sampling, repeated cleaning and disinfection of various areas of the JLV-VTH, and increased use of personal protective equipment, the hospital administrators in consultation with the authors judged that the mitigation efforts were sufficient to preclude the need for closure. However, it should be noted that had hospital closure been enacted on Day 20 when multiple animals were known to be infected, subsequent infection of the Cow A and Horse B could have been avoided. Clearly, decisions regarding management of a nosocomial outbreak can be controversial. It is the authors' collective opinion that such decisions should be retrospectively critiqued as carefully as are the decisions regarding management of a patient with a complex clinical problem.

Movement of hospital personnel and animals within the facility likely contributed to the dissemination of environmental contamination in this outbreak. Sampling for ENV-H surveillance at the JLV-VTH intentionally focuses on personnel

traffic areas and hand-contact surfaces because of the importance of unintended spread through contact of personnel with infected patients and their environment. Among the ENV-H samples, those obtained from floor surfaces were more frequently positive than those obtained from hand surfaces, suggesting that human and/or animal foot traffic contributed to environmental dissemination, in spite of the presence of multiple disinfectant footbaths throughout the large animal facility. Detection of the Outbreak Strain in ENV-H samples obtained from hand-contact surfaces indicates that personnel contributed directly to environmental dissemination, despite a strict hand hygiene policy that had been in place prior to and during the outbreak. Oral exposure to patients and personnel may be more likely to occur when hand surfaces are contaminated. Clearly, maintaining awareness among personnel regarding the importance of effective hand hygiene is essential in a hospital infection control program.

Environmental persistence of the Outbreak Strain was most problematic in the equine isolation unit. Careful inspection of areas where feces, bedding and other debris can persist after cleaning and disinfection should be promptly initiated when persistent environmental contamination is detected in a hospital, perhaps by an individual not directly involved in cleaning or sampling of that environment. During the outbreak, the sampling methodology used in the equine isolation unit was changed from the ENV-S to the ENV-H because the electrostatic wipes visibly appear to collect more particulate debris from the environment than do premoistened sponges, potentially resulting in a greater sensitivity for detection of *Salmonella* in the environment. Further research is needed to measure and compare the

sensitivity of each method in detecting environmental contamination with salmonella.

While rigorous patient and environmental sampling was employed before and during this outbreak, it is possible that other patients were infected and shedding the Outbreak Strain without being detected. For example, a stall in the agricultural animal ward was found to be contaminated with the Outbreak Strain, despite the fact that a patient known to be infected did not occupy this stall. Cultures for *S. enterica* are notoriously insensitive, even though techniques used at the CSU-VDL have been evaluated and optimized through inter-laboratory comparisons. Increasing sampling frequency would have increased the likelihood of detecting low level or intermittent shedding in subclinically infected animals. However, because of our relatively extensive experience with active surveillance for *S. enterica* shedding in patients, we believe that this sampling strategy was sufficient to detect shedding that represented a significant threat for nosocomial transmission.

Footnotes

[a] Swiffer®, Proctor & Gamble, Cincinnati, Ohio, USA
[b] HydraSponges, International BioProducts, Redmond, WA 98073
[c] Virkon-S, Suffolk, UK
[d] Tetrathionate Broth, Difco, Lawrence , Kansas, USA
[e] Thioglycollate Broth, BD, Franklin Lakes, NJ, USA
[f] Buffered peptone water, Difco, Lawrence , Kansas, USA
[g] Rappaport-Vassiliadis Broth, Difco, Lawrence , Kansas, USA
[h] XLT, Hardy Diagnostics, Santa Maria, California, USA
[i] TSA, BD, Franklin Lakes, NJ, USA
[j] 1% Agarose, Oxoid Limited, Hampshire, UK
[k] *Xba*I, Promega, Madison, Wisconsin, USA.
[l] CHEF Mapper Pulsed Field Electrophoresis System, Bio-Rad Laboratories, Hercules, Calif.
[m] Tris-borate-EDTA, TBE, Sigma-Aldrich, St. Louis, Missouri, USA

[n] Bionumerics, Applied Maths Scientific Software Development, Belgium.
[o] Tingley Rubber Corporation , So. Plalinfield, NJ, USA
[p] Tempa-DOT, 3M, St. Paul, Minnesota, USA
[q] Footmats, Gemplers, Madison, Wisconsin, USA
[r] 456N, Ecolab, Inc., St. Paul, Minnesota, USA
[s]H. Aceto, University of Pennsylvania, personal communication, 2008.

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Table 7.1. Recovery of *Salmonella enterica* from the JLV-VTH environment and patients during 2006.

Percent *Salmonella*-Positive (number/total)			
Time Period (2006)	***S. enterica* Serotype**	**Environmental[1] Samples**	**Fecal Samples from Large Animal Patients**	**Large Animal Patients**
Jan 1 - July 28	Newport	0%	0%	0%
	Other	2.5% (13/517)	0.7% (7/1008)	1.1% (6/545)
July 29 - Sept 1	Newport	19.7% (37/188)	7.3% (18/245)	6.6% (9/154)
	Other	4.8% (9/188)	5.7% (14/245)	6.6% (9/154)
Sept 2 - Sept 29	Newport	4.3% (6/139)	0%	0%
	Other	11.5% (16/139)	7.7% (14/182)	14% (13/80)
Sept 30 - Dec 31	Newport	0%	0.2% (1/489)	0.4% (1/269)
	Other	13.3% (33/249)	5.1% (25/489)	9.8% (24/269)

[1] Includes all types of environmental samples obtained from the JLV-VTH.

Table 7.2. Recovery of *Salmonella enterica* from environmental samples collected August 14 through September 29, 2006.

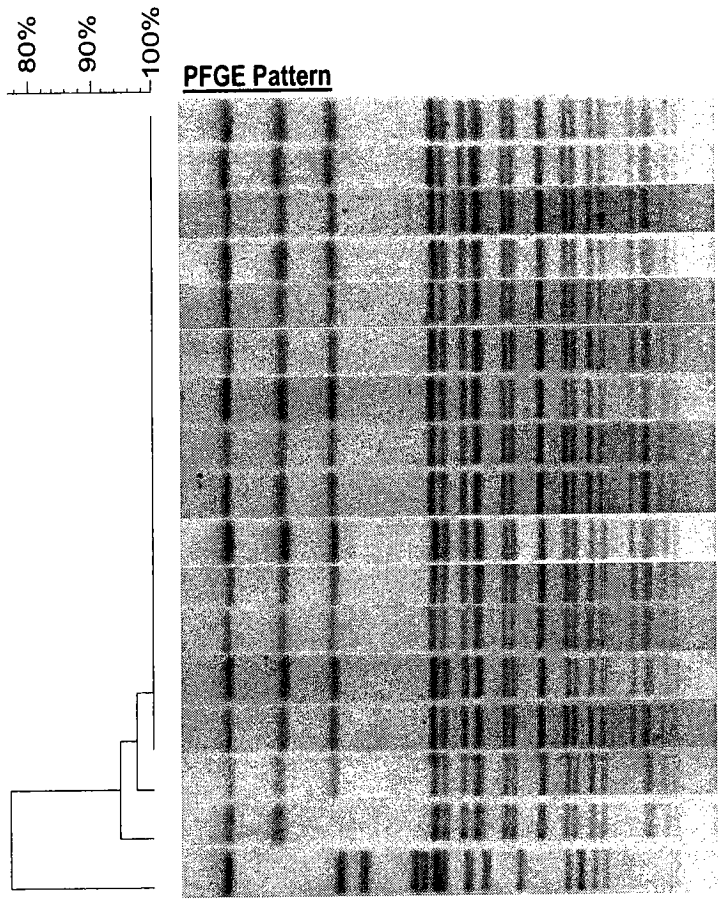
Area Sampled	Sample No.	Recovery of *Salmonella enterica*			
		Pct. Positive for Outbreak Strain (No.)		Pct. Positive For Other Strains (No.)	
Agricultural Animal Ward (ENV-H)	79	26.6%	(21)	15.2%	(12)
Equine Ward (ENV-H)	115	4.3%	(5)	4.3%	(5)
Equine Isolation (ENV-H)	33	33.3%	(11)	0.0%	(0)
Other JLV-VTH Areas (ENV-H)	57	3.5%	(2)	7.0%	(4)
CSU Veterinary Diagnostic Laboratory (ENV-H)	8	25.0%	(2)	0%	(0)
Parking Lot (ENV-H)	3	33.3%	(1)	33.3%	(1)
Large Animal Stalls (ENV-S)	32	3.1%	(1)	9.4%	(3)
TOTAL	327	13.1%	(43)	7.6%	(25)

Figure 7.1. Schematic diagram of the large animal hospital showing approximate location of environmental samples from which the Outbreak Strain of *S.* Newport was recovered and the stabling locations of patients confirmed to be shedding the Outbreak Strain. Sites of samples that were culture-negative are not shown. For stabling location indicators, the first letter indicates patient species (A = Alpaca, C = Cow, G = Goat, and H = Horse), and the second letter (A-D) identifies the specific patient referenced in the manuscript and Figure 2. Dots indicating environmental sample locations do not represent the extent of the surface area that was actually sampled. Samples in stalls were only obtained after prescribed decontamination.

Figure 7.1

Figure 7.2. Results of pulsed-field gel electrophoresis (PFGE) and comparison of genetic relatedness for representative isolates of the Outbreak Strain of *Salmonella* Newport (isolates A-N), and comparison isolates of *S.* Newport (isolates O-Q) that were recovered from animals that had no known epidemiological links to the JLV-VTH or the outbreak. All samples were collected in 2006. Pattern No. = unique PFGE pattern identified within the VetNet database (170 = pattern JJPX01.0170; 048 = pattern JJPX01.0048; 338 = pattern JJPX01.0338). Environ = Environmental sample (AG = agricultural animal ward; EQ = equine ward; SA = small animal hospital).

Figure 7.2



Isolate	Pattern No.	Source	Sample Date	Genetic Similarity
A	170	Alpaca A - Feces	Aug 8	Reference
B	170	Alpaca A - Feces	Aug 15	100%
C	170	Alpaca B - Feces	Aug 11	100%
D	170	Alpaca C - Feces	Aug 15	100%
E	170	Alpaca D - Feces	Aug 18	100%
F	170	Goat A - Feces	Aug 18	100%
G	170	Horse A - Feces	Aug 18	100%
H	170	Horse A - Feces	Aug 22	100%
I	170	Horse A - Spleen	Aug 23	100%
J	170	Horse B - Feces	Sep 1	100%
K	170	Environ - AG Medication Rm	Aug 14	100%
L	170	Environ - AG Treatment Rm	Aug 22	100%
M	170	Environ - EQ Outpatient	Aug 22	100%
N	170	Environ - SA Anesthesia Prep	Aug 14	100%
O	048	Outside Cow - Feces	Aug 11	97%
P	023	Outside Dog - Feces	Jun 30	95%
Q	338	Outside Horse - Feces	Jul 26	77%

Chapter 8: Antimicrobial resistance monitoring: review of data streams used in the U.S. system

This chapter straddles the categories of outreach and needs assessment. This chapter is intended as outreach to inform and stimulate discussion on the public health issues of the national antimicrobial drug resistance monitoring system (NARMS) in the United States. This chapter is also in part a needs assessment, reporting on what the process of antimicrobial drug monitoring is, and taking it a step further and exploring and assessing needs for a better process. This paper was developed to help determine program needs and inform on policy in a changing environment. Co-authors are Ashley Hill and Dave Dargatz.

Antimicrobial resistance monitoring: review of data streams used in the U.S. system

The discovery of antimicrobial drugs (AMD) is an event that has forever changed the face of human health. The use of AMD along with public health improvements have led to a dramatic drop in human deaths from infectious disease, and greatly increased life expectancy.[1]

Bacterial resistance to AMD was observed soon after their discovery. Resistance is a natural biological phenomenon. Some bacteria are inherently resistant to certain antimicrobials while others acquire resistance through selective pressure exerted with AMD use. [2] The bacteria that survive these selective pressures carry genes for resistance, which can be passed horizontally or vertically to other bacteria.[3] In some cases these resistance genes can also be transferred to other

types of closely or not so closely related bacteria so that resistance to a single drug can spread between bacterial populations.

Any use of antimicrobials, whether in humans, animals, plants or food-processing, has the potential to select for resistant bacteria. Inappropriate use of antibiotics increases the likelihood that resistant forms of bacteria will be selected. [4]The issues of use and misuse of antimicrobials in the food chain are of global concern and there is a pressing need to promote more prudent antibiotic use in every setting – human medicine, animal medicine, and agricultural production. [5]

The consequences of AMD resistance are serious and are a major public health concern on a global level. When infections fail to respond to treatment, prolonged illness occurs, and more individuals may be exposed to infectious disease agents. Treatment failures with first line antimicrobials lead to the use of second or third line drugs which are usually much more expensive, potentially more toxic and create difficulties in hospitals that are trying to treat these drug resistant patients.[6] Prolonged and additional illness results in increased medical costs. [7] The increased cost of treating resistant infections may be prohibitive, especially in developing countries. Concern has been raised that if current trends in antibiotic resistance continue, the pharmaceutical industry will not be able to keep up with new replacement drugs and some infectious agents will have no effective antimicrobial treatment.[7]

In addition to human use, AMD are also used to treat or prevent disease in food animals, aquaculture, companion animals and in horticulture. Animals are prescribed AMD for all the same reasons as humans and AMD are also used in food

animals for growth promotion. Antimicrobials used in animals are often the same, or closely related to the antimicrobials used in humans. If bacterial populations in animals become resistant to AMD, this resistance can potentially be passed on to humans via food-borne or zoonotic pathogens or via transmission of resistance genes to human pathogens. [8-10]

What is the contribution of AMD use in humans and animals to the overall picture of AMD resistance? To what extent is AMD resistance transferred between animals and humans and what is the resulting impact on human health? The answers to these questions are largely unknown. The potential for AMD resistance in animal bacteria to impact AMD resistance in human bacteria is a hotly contested issue with both sides presenting information as well as conjecture. To gain knowledge on these important issues, AMD resistance monitoring and surveillance on a global level for both humans and animals is essential.

Monitoring and surveillance programs serve as early warning systems that can detect trends in incidence and prevalence of AMD resistance, changes in susceptibility, and thus emergence of antimicrobial resistance at an early stage. The data generated through monitoring and surveillance programs help identify spatial and temporal trends in AMD resistance and can be used in risk analyses to estimate risks to human and animal health, to identify the need for interventions, and to assess the consequences of emerging resistance patterns. The analysis of antimicrobial drug resistance surveillance data can provide a basis for policy recommendations for animal and public health; guide the design of further studies;

and provide data to inform prescribing practices and prudent use recommendations.

The U.S. and most European countries have developed surveillance systems to monitor antimicrobial resistance. This paper will describe the U.S. monitoring system for enteric bacteria, the streams of data collected, and advantages and limitations of each stream.

The US System - NARMS

The National Antimicrobial Resistance Monitoring System – Enteric Bacteria (NARMS) was established in 1996 as collaboration among the Food and Drug Administration's Center for Veterinary Medicine (FDA CVM), U.S. Department of Agriculture (USDA) and the Centers for Disease Control and Prevention (CDC). NARMS monitors antimicrobial drug susceptibilities of selected enteric bacterial organisms in human and animal samples as well as retail meat samples.

Human bacterial isolates are collected by medical practitioners from clinical human enteritis cases and are submitted through state and local public health laboratories to the CDC laboratory in the National Center for Zoonotic, Vector-Borne and Enteric Disease (NCZVED) in Atlanta, Georgia. Animal isolates are submitted to the Agricultural Research Service (ARS) laboratory in Athens, Georgia. Animal isolates include bacterial isolates from clinically ill animals, healthy animals on-farm from research studies conducted by the USDA or collaborators, and from federally inspected animal slaughter facilities. Retail meat isolates are collected in select states and are submitted to the Food and Drug Administrations Center for Veterinary Medicine (FDA-CVM) laboratory. [9]

Microbiological susceptibility testing for bacterial isolates from human clinical cases, animal clinical cases, slaughter animals, retail meat and healthy on-farm animals are presently standardized to the degree possible. *Salmonella, E. coli, Campylobacter sp.*, and *Enterococcus sp.* isolates are tested against a panel of antimicrobials. All isolates are tested following the guidelines from the Clinical Laboratory Standards Institute (CLSI, formerly NCCLS).

The five "streams" of samples are: animal clinical case isolates, human clinical case isolates, slaughterhouse isolates, retail meat isolates, and isolates from on-farm healthy animals. Each provides their own piece of the larger picture of antimicrobial resistance and its own limitations.

Animal clinical case isolates

Sampling

Animal clinical isolates are obtained from samples submitted to veterinary diagnostic labs for culture from sick animals. These samples can be submitted by farmers, veterinarians in the field, from veterinary clinics or veterinary teaching hospitals. Samples that culture positive for *Salmonella, Campylobacter, Enterococcus,* and *E. coli* are then sent to the National Veterinary Services Laboratory (NVSL) for serotyping (*Salmonella)* or directly to the ARS for further characterization and antimicrobial resistance testing (*Campylobacter, Enterococcus, E. coli).* A predetermined number of samples per species are evaluated each year and included in NARMS data.

Advantages

Collection of these samples and documentation of their resistance patterns allow us to compare and follow trends in animal AMD resistance. An advantage of these readily available isolates is that they may be useful in signaling emergence of new pathogens, e.g. increased prevalence of a particular *Salmonella* serotype. As such, they may provide an early warning system for the emergence of resistance to a particular AMD.[11] In addition, these isolates give some indication of what is being seen in clinical cases, so they might help to guide AMD selection for treating the animals.

Limitations

The samples submitted for testing are probably not representative of the general population of clinical cases of disease. The magnitude of effect of a particular disease on a farm impacts the decision to seek an etiologic diagnosis by submitting a sample to a veterinary diagnostic lab. Because diarrhea or soft stools are fairly common, most cases are treated on farm without laboratory diagnosis. Samples taken during disease outbreaks may be more likely to be submitted to diagnostic labs than isolates from individual cases. [12] Samples submitted for testing are also likely to be part of a herd problem in which the disease has occurred with unexpectedly high frequency or with particularly severe effects (morbidity rates, mortality rates, production effects).

In addition, samples submitted from animals that fail to respond well to standard treatments may have been previously treated with AMD. As a result, bacterial isolates from diagnostic submissions are more likely to be from animals that are undergoing AMD therapy, or animals with a history of AMD use and/or

treatment failure. [13, 14] If this AMD therapy selected for resistant bacteria then AMD resistance would be higher in these animal samples. For all of these reasons it is likely that this surveillance stream will over-represent AMD resistance frequency.

Care must be taken in interpretation of the data because testing procedures change and may affect the apparent distribution of AMD over time. For instance, prior to 2002 naladixic acid susceptibility and cephalothin resistance were initially used as identification criteria for *Campylobacter jejuni/coli.* This likely resulted in an underreporting of quinolone/floroquinolone resistant *Campylobacter* until 2001 when use of this method was discontinued.

Human clinical case isolates

The process of collecting AMD resistance data on human clinical cases begins when a patient seeks medical care. To help determine the cause of the illness, a physician may rely on a lab test, which could be performed at the physician's own office, a hospital, an independent clinical laboratory or a public health lab. If the test shows that the patient is infected with a disease that must be reported under state law (reportable diseases vary by state but most state lists include *E. coli 0157:H7, Salmonella, Campylobacter* and *Shigella*), or if the physician diagnoses a reportable disease without the use of a test, the cases are usually reported to the local or state health department. Health department staff collects the reports and forward them to state health agencies. An electronic laboratory reporting system, the Public Health Laboratory Information System (PHLIS) collects information from all 50 state public health laboratories.

Sampling

Sampling for AMD resistance from human isolates depends on public health laboratory-based surveillance and is driven by the occurrence of laboratory-confirmed cases. When the NARMS program began in1996 it initially included monitoring of antimicrobial resistance among non-Typhi *Salmonella* and *E. coli* O157 isolates in 14 states. Testing of *Salmonella* Typhi and *Shigella* isolates was added in 1999. Since 2003, *Salmonella*, *Shigella*, and *E. coli* O157 isolates have been collected from clinical laboratories by state and local health departments in all 50 states and sent to the CDC for susceptibility testing. In 2003, participating state and local public health laboratories sent every 20th non-Typhi *Salmonella*, *Shigella*, and *E. coli* O157:H7 isolate they received. *Salmonella* serotyping was performed by the participating laboratories prior to shipping. All isolates of *Salmonella* Typhi, *Listeria monocytogenes*, and noncholerae *Vibrio* isolates were also forwarded to CDC for further analysis.

Surveillance for *Campylobacter* began in 1997 with five FoodNet sites submitting one isolate each week. This was expanded through the years, and in 2003 included isolates submitted from 10 FoodNet sites. Since not all states require submission of *Campylobacter* isolates from clinical laboratories, some states receive isolates from almost all clinical laboratories in their jurisdiction (five sites) while others receive isolates from sentinel laboratories (five sites).

FoodNet is a surveillance system that operates at state or local public health departments in ten states: California, Colorado, Connecticut, Georgia, Maryland, Minnesota, New Mexico, New York, Oregon and Tennessee. They conduct active surveillance on food borne illness. Public health departments that participate in

FoodNet receive funds from CDC to systematically contact laboratories in their geographical areas and solicit incidence data.

Advantages

The advantages of determining resistance patterns in human clinical isolates are the same as those of animal clinical cases: they are readily available and may be used to identify emergence of new pathogens or resistant forms of existing pathogens. The pathogens and their resistance patterns can be compared from year to year through analysis of the NARMS data to identify trends and may be used to guide empirical treatment.

Limitations

Very few people who contract a food borne illness actually seek treatment, are properly diagnosed, or have their diagnosis confirmed through laboratory analysis and subsequently have their cases reported through the surveillance system. A recent CDC study estimated that there are 3.4 billion cases of acute diarrheal disease in the US and only 7% of people who were ill sought treatment. [15] It is estimated that physicians requested lab testing for only 22 percent of those diarrheal patients who sought treatment which produced about 6 million test results.

As with bacterial isolates from animal clinical cases, diagnostic submissions from humans may be from individuals who have a history of antimicrobial use and/or treatment failure. AMD's are available over the counter for animal use without diagnosis or veterinary intervention so that prior use of AMD in animals may be greater than it is for humans. Still, human diagnostic samples may have been

submitted after initial treatment failure, in which case antimicrobial therapy may have been used prior to sample collection. If some diagnostic submissions were from humans who had already undergone AMD therapy, and this therapy selected for resistant bacteria, then AMD resistance would be higher in this stream than in the larger population of humans with gastroenteritis. The use and effect of previous AMD therapy in both animal and human clinical case samples is unknown because relevant data on AMD history are not collected at the time of sample submission.

Not all collected bacterial isolates are tested for antimicrobial resistance. Public health labs are instructed to keep a running count of all submissions, and then select every 10th or 20th isolate to submit to the CDC. According to the 2002 NARMS report, an area of potential bias could be the increased selection of "interesting" or more resistant isolates if the established sampling policy is not followed thereby leading to over-representing antimicrobial resistance.

The sampling system, which is proportional to the number of samples submitted, could skew data towards a particular resistance profile. If states are sending in every 10th or every 20th sample and one state has a food borne disease outbreak, then that state will be sending in a disproportionately large number of samples, all from a very similar isolates. For example in a 2006 *E. coli* outbreak associated with spinach a large number of identical isolates are submitted.[16] These isolates, although probably not representative of gastroenteritis pathogens in the general population, may skew an entire year's AMD resistance profile because of the number of samples submitted.

According to a Government Accounting Office report, staffing and technology shortages are common at the state level. State and local health departments often lack trained epidemiologists. Standardized reporting among states is deficient as are state laboratory capabilities. [15] The resulting failure to analyze, report and include disease data, may lead to over or under-representation of AMD resistance.

Slaughterhouse isolates

Slaughterhouse samples are provided by the Food Safety and Inspection Service (FSIS). *Salmonella* and *Campylobacter* isolates are submitted by FSIS to NARMS from its regulatory HACCP (hazard analysis and critical control point) Verification Testing Program.

Carcasses that are sampled for bacterial isolates have passed ante mortem inspection. Animals with signs of sepsis, fevers, or diarrhea, and animals that are non-ambulatory or have other evidence of disease are diverted from the food chain to protect human health. The reasons for animals being sent to slaughter vary from reaching market weight to culling due to poor health, low productivity or other factors.

Sampling

FSIS regulations require that a subset of beef, swine and chicken carcasses at slaughterhouses be sampled for *Salmonella* testing. Since 2000, all samples collected are included in NARMS data. Ground products including beef, chicken and turkey are also sampled.

The number of animal carcasses tested at slaughter facilities is based on sample sets which vary by species. A sample set consists of 51 samples for broiler carcasses, 58 samples for cow and bull carcasses, 55 samples for market hog carcasses, 82 samples for steer and heifer carcasses, and 53 samples for raw ground beef, ground chicken and ground turkey. Samples are collected by FSIS employees assigned to a particular facility. Samples are collected randomly when directed to do so by FSIS headquarters in Washington DC to determine whether an establishment meets FSIS required standards. One sample per slaughter day is collected until the sample set is complete. This would take, for example, 51 days for a poultry establishment that slaughters every day, or 102 days if it slaughtered every other day. [17]

Salmonella samples are collected from beef, swine and turkey carcasses using a sponge technique or tissue excision technique. Sponge sites for beef include the flank, brisket and rump except for hide-on calves, in which case samples are sponged from inside the flank, inside the brisket and inside the rump. Sample sites for swine are collected by sponge or excised tissue from the belly, ham and jowl areas. For turkey, sample sites include back and thighs. Chickens are sampled for *Salmonella* and *Campylobacter* using whole bird rinses (rinsates). Samples for ground product consist of 25 grams of the product.

Advantages

This stream constitutes a large number of isolates that represent samples relatively close to the consumer on the food chain. Because sampling is already

being done for regulatory purposes, data from this source are relatively easy to obtain.

Limitations

As FSIS itself states, bacterial isolates/samples are collected to determine whether an establishment meets regulatory standards and not for scientific interpretation or research purposes. As such, sample collection is not random and is not based on production volume for specific species so data obtained may not reflect the underlying prevalence of *Salmonella* and any resulting antimicrobial resistant isolates.[18] This could over or under represent antimicrobial resistance in slaughter samples.

Because facilities that do not pass the first round of testing may be tested again during the same calendar year, facilities with higher levels of *Salmonella* may be over-represented. Because they contribute a large proportion of samples, resistance profiles of *Salmonella* isolates from these facilities may skew overall resistance data.

Samples are collected for the most part during a condensed period of time and not distributed evenly over a calendar year. Previous research has indicated that fecal shedding of *Salmonella* varies due to season and possibly geographical location. [19]Without an even distribution of sampling, possible seasonal, geographic or facility differences in antimicrobial resistance patterns would be missed. In addition, *Salmonella* serotype and prevalence have been shown to vary from farm to farm and within farm depending on sampling time. [20] If certain serotypes are more prevalent during certain time periods, this type of sampling may select for more or

less resistant *Salmonella.* This sampling scheme could over or under-represent AMD resistance.

It is difficult to determine the source of AMD resistant pathogens in slaughter samples. Contamination with AMD resistant bacteria could have come in with the animal, been introduced through lairage where numbers of animals from different sources might share pathogens, or through poor hygiene at the slaughter facility through contaminated fomites or workers.

The role of stress on bacterial shedding must also be taken into consideration when interpreting surveillance data. Stress can cause changes in bacterial ecology within the intestine. Cold stress has been shown to cause increased excretion of resistant bacteria in pigs. [21]Transport stress increases excretion of *Salmonella* in calves and also susceptibility to challenge with bacteria. [22] Although we might expect slaughter samples, which are relatively close to the human market to have lower prevalence of antimicrobial resistance than samples from clinical cases, the role of stress may increase the overall prevalence of AMD resistance in slaughter samples.

According to the FSIS, statistically based sampling protocols, separate from the current regulatory sampling program, would be necessary to evaluate the importance of factors such as transport, lairage, geographic features, seasonality, or establishment size on the serotype prevalence and distribution of *Salmonella* in slaughterhouse samples. [18]

Retail Meat isolates

The retail meat surveillance program utilizes ten FoodNet laboratories in the states of California, Connecticut, Georgia, Maryland, Minnesota, New York, Oregon and Tennessee to monitor the presence of antimicrobial resistance among *E. coli*, *Salmonella*, *Campylobacter* and *Enterococcus*. Convenience samples of fresh meat and poultry are purchased monthly from grocery stores. The sample isolates from ground turkey, ground beef, chicken breast and pork chops are then subjected to standardized antimicrobial susceptibility testing methods in order to determine the prevalence of resistance.

Sampling

In 2002, retail meat sampling began in January with FoodNet laboratories in Connecticut, Georgia, Maryland, Minnesota and Tennessee; Oregon joined in September. For calendar year 2003, retail meat sampling was expanded to include California and New York. An attempt was made by each FoodNet site to sample as many different stores as possible each month. The object was to purchase as many different brands of fresh (not frozen) meat and poultry as possible. A total of 40 food samples were purchased per month including 10 samples each of chicken breast, ground turkey, ground beef, and pork chops (the exception being CT, which only collected 5 samples each for 2003). For each meat and poultry sample, the FoodNet sites recorded the store name, brand name, lot number (if available) sell-by date, purchase date and lab processing date on log sheets. Additional information with regard to whether or not the meat or poultry was ground or cut in-store was also collected, if possible. Samples were kept cold during transport from the grocery store(s) to the laboratory. Once isolated and identified, bacterial isolates were sent

to the FDA—CVM Office of Research for further characterization including species confirmation and antimicrobial susceptibility testing.

Advantages

Not only are these bacterial isolates are very easy to obtain, these healthy animal isolates give us information on potential contamination very close to the consumer.

Limitations

The source of contamination of retail meat samples is unknown. Resistant bacteria could be found in these samples by contamination at the slaughterhouse, during transport from the slaughterhouse to the grocery store, or in the grocery store by food processing machines, knives, workers hands or cutting boards. In addition, exceeding regulated temperatures at any time during the path from slaughterhouse to wrapped product could amplify any bacteria present. The number of bacteria or the AMD profiles of bacteria may not reflect what was present in the live animal. Data from retail meat samples may over-represent antimicrobial resistance in animals themselves because cross contamination could occur from one source and affect many batches of meat.

Although the 10 FoodNet sites are distributed geographically, some states and regions may be under or over represented. If resistance profiles differ by region, over or under representation of antimicrobial resistance would result.

It is not clear from the sampling scheme description whether meat samples are collected over the entire state, just in metropolitan areas or based on population

density. Without knowing more about the sampling strategy, caution should be used in generalizing the AMD profiles of FoodNet retail meat samples to the entire nation.

Healthy animals isolates (On-farm animals)

Bacterial isolates from national studies in the National Animal Health Monitoring System (NAHMS) are included in NARMS data as they become available. Typically one livestock commodity (dairy, beef, poultry, equine, aquaculture, and others) is studied each year which results in the collection of data on each commodity approximately every five years. NAHMS is a nationwide study of management and health issues relating to each commodity and is a cooperative effort between State and Federal agricultural statisticians, animal health officials, university researchers and extension personnel. Field isolates from various studies conducted by ARS may also be included in the data attributed to healthy animals.

Sampling

A stratified random sample of farms is chosen each year for the NAHMS studies. Generally a convenience sample of these farms and animals on those farms is chosen for the collection of biological samples including feces. In some cases the biological samples are not collected from individual animals but rather from the environment. An attempt is made to be representative of the healthy on-farm population. Depending on the commodity, states and regions are chosen which are representative of the distribution of that commodity. For example the 2002 dairy study was conducted in 21 states that contain 79% of dairy herds in the U.S.

Advantages

These healthy animal samples are a comparison group for clinical animal cases. They provide a baseline for comparison of healthy to sick animals. In general, these healthy animals on the farm represent the animals that may be presented for slaughter to become part of the food chain. The resistance profiles in these animals will generally be the product of the environment that they live in and the management procedures that they are subject to.

Limitations

Because each commodity is only studied approximately every five years the interval between measurements does not lend itself to timely monitoring. This greatly limits the usefulness of overall comparisons that include healthy animal data. This stream also contributes a relatively low number of isolates, compared to the number of samples submitted via the other data streams.

NAHMS collects general information on antibiotic use, the reasons producers use antibiotics, the method of administration of antibiotics to the animals and the size of the producers operations. Information about the quantities of antibiotics used and specific animal antibiotic use data has not been collected. [5] Because exposure to antibiotic treatment may affect bacterial susceptibility this information would be helpful for interpretation. In response to the recognition that this type of information would be desirable, recent NAHMS surveys have increased the collection of this type of information.

Discussion

Are the goals of NARMS being met?

NARMS was established to monitor for the development of AMD resistance in enteric bacteria, facilitate AMD resistance identification when it arises, prolong the life span of AMDs, and inform veterinarians and physicians of AMD resistance patterns in a timely fashion as well as spur investigations if necessary. NARMS is only a general indicator for AMD resistance. Additional, more focused analytical studies must follow to determine why and how AMD resistance has occurred and how to best mitigate its emergence. [6]According to NARMS, generated data have been used to support field investigations of outbreaks, to provide data for risk assessment of the human health impact of AMD (e.g. fluoroquinolone use in poultry), and to stimulate research in molecular characteristics of resistance emergence and transfer. [23] Improved knowledge of risk factors associated with the development of an AMD resistant infection has triggered broader research projects on the prudent use of AMD in animals and the role of the environment in the emergence and spread of AMD resistance.[23] Many of the problems with NARMS data (i.e. lack of timeliness of reporting, lack of inclusion of relevant data on AMD use history, more timely acquisition of species data in healthy on-farm animal isolates, more random system of data collection in slaughter samples) would likely be improved upon with increased funding and personnel appropriated devoted to helping NARMS meet its important goals.

Do the data help answer the questions that need to be answered by AMD resistance data?

Important questions relating to AMD resistance include determination of incidence, possibility for transmission between humans and animal, determination of threshold levels for action and optimal mitigation strategies.

According to the World Health Organization, information is needed on the true incidence of antimicrobial resistance in the animal population and how this incidence varies over time. NARMS attempts to accomplish this. Incidence data have been collected continuously since 1996 allowing for trend analysis for some categories of isolates, which can provide useful information about patterns of emerging resistance and guide efforts to mitigate antimicrobial resistance.

A potential problem with AMD resistance data occurs with failure to take into account the underlying sampling scheme. When conclusions are made from NARMS data that the reported numbers of cases of AMD resistance represent AMD resistance in the entire population (or entire country) we are misinterpreting the data. These data should not be used to answer questions but rather to generate interesting questions for further research. While the scientific community may be well aware of the application of the data, the general public may need better discussion and explanation to understand its implications.

Does the existence of antimicrobial resistance relate to a risk or a probability of acquiring a resistant infection? What is the nature and the degree of transfer of resistance that occurs between animals and humans? What have we learned about the transmission of AMD resistance? Statistically valid quantitative studies are essential for assessing the potential impact of the use of AMD on AMD resistance and its relevance to human and animal health. [11]These questions were posed when

NARMS was formed in 1996 and are still being asked today. Temporal and spatial analysis of the data may help answer some of these questions.

When is it necessary to do something about resistance in a bacterial strain? What are the threshold levels that will be tolerated and what actions will be taken if those thresholds are crossed? What are the consequences of restriction or withdrawal of a particular AMD for use in animals? The data provided by NARMS may not answer these questions directly but interpretation of the collected data will help policy makers come to better informed decisions.

Where should mitigation efforts be directed? Potential areas for mitigation could be directly suggested by NARMS data. For example, though small in numbers the retail meat stream suggests bacterial contamination at some point in the stream is occurring. Directed efforts to determine where this contamination is occurring could significantly change the resistance prevalence found in retail meat.

Information is being gathered but questions remain that make interpretation and usefulness of the data difficult to discern. These include lack of AMD usage data, non-harmonized lab testing, lack of information on sub-groups and timeliness.

Lack of detailed information on the type and quantity of AMD usage in humans and in animals is a barrier to interpretation of data. As previous exposure to antibiotic treatment may affect bacterial susceptibility, knowledge of antibiotic history is clearly desirable. Collection of medical and/or antimicrobial use histories on all animal and human clinical cases would be cumbersome; but it would be very useful in interpreting susceptibility data.[5, 13]

Non-standardization of culture protocols and resistance testing between laboratories makes interpretation and comparison problematic. For example, the type of bacterial colony chosen for resistance testing is not standardized. [24]Efforts at harmonization of protocols across laboratories as well as across continents will allow for comparison and consolidation of results and is essential for effective surveillance of AMD resistance. [13, 25, 26]

In the animal arm of NARMS data, lack of information on subgroups within a species such as age (juvenile or adult) or type (beef, dairy, or veal) is also a barrier to interpretation. [12]This information would be especially useful in mitigation efforts. Recent studies for instance, have shown increased rates of AMD resistance in veal calves versus dairy or beef calves. [27] The age of animals used for resistance data should also be identified as the resistant bacteria isolated from animals varies with the age of the animal. For example fecal isolates from calves show a higher incidence of resistance in their intestinal flora than samples from adult animals. [28] In general, subgroup data would help to focus further studies and aid in mitigation efforts.

A hurdle in the usefulness of NARMS data is its timeliness; it often takes several years for the data to become available. According to a Government Accounting Office report delays in the publishing of data from NARMS diminish the usefulness of the system. [5]

Does monitoring of these five streams of data provide us with a good picture of AMD resistance in the U.S.? Should other streams considered for inclusion in NARMS?

Are we looking at enough data from enough different sources to give us the big picture? A broader context in which AMD use overall was considered would benefit all interested parties.[29] Other streams of AMD resistance monitoring that could be considered include:

Commensal bacteria isolates from healthy humans and animals. The use of AMD in humans and animals not only increases resistance in pathogenic bacteria, but also in commensal bacterial, the normal bacterial flora of the gastrointestinal system. Resistance in commensal flora is comparable with resistance in pathogenic bacteria and some studies have shown that commensal flora is an important reservoir for resistance genes. [14,30] AMD resistance (from non-pathogenic bacteria to pathogenic bacteria) may be transferred to humans and/or animals by direct contact or through food products of animal origin.[31] Companion animals may play a role in this as well. Resistance in pathogenic bacteria is only the tip of the AMD resistance iceberg and data on the prevalence of antibiotic resistance in commensal bacterial would be very useful to include in NARMS data. [31]

Environmental samples: AMD residues from human or animal use can be found in rivers, seas, sewage and in arable soils. [32, 33] Fluoroquinolone antibiotics have been identified in human hospital waste water. Little is known about the effects of these agents in the environment and their potential effect on the development of resistance. Transfer of AMD resistance can occur not only from animals to humans, but from humans to animals. Resistance determinants that have previously been selected in humans have been detected in animals[34] and environmental contamination may play a role. The addition of environmental

samples in NARMS data, including surveillance of sewage treatment plants might add valuable information on where and how resistance is developing and could aid in mitigation.

Horticulture: According to the World Health Organization there is insufficient information on antimicrobial resistance in many areas, especially horticulture and aquaculture. Plants and vegetables can be contaminated with resistant bacteria by exposure to manure or sewage from livestock or humans or through spraying with AMD pesticides. [13] Presently there are two AMD approved for use in plants, streptomycin (aminoglycoside class) and oxytetracycline (tetracycline class).[5] Systematic data collected on the use and resulting AMD resistance found in plants and vegetables would be an appropriate addition to NARMS.

Aquaculture: Antimicrobials are commonly used in the treatment of farmed fish in the United States. Because of the environment in which fish are raised, AMD used in farmed fish flow out of production facilities into open waterways or sewage systems. Oxytetracycline, sulfamerazine and sulfadimethozine-ormetoprim are commonly used AMD and florfenicol has just been approved for use in farmed catfish. The most recent NAHMS study focused on aquaculture, but data on antimicrobial resistance in farmed fish was not collected or published. As the consumption of farmed fish increases, so does the need for greater focus on the use and resistance of AMD in this industry.

Animal feed/slurry: Contaminated feed has been shown to be a source of dissemination of bacteria such as salmonella. [9] The presence, prevalence and impact of resistant bacteria in feed with the development of AMD resistance in animals and

humans is unknown. Data collected in this area and compared with other streams might yield an important point for mitigation efforts.

Data from other countries. When we compare our AMD resistance data to other countries (developed and developing countries) what do we learn? Are the resistance profiles similar? If data were collected in a harmonized fashion, at various levels (animal, human, and environment) they could be compared at the international level.

The problem of antimicrobial resistance might be a problem of greater magnitude in developing countries because of preponderance of infections and wide misuse, overuse or abuse of antimicrobial agents.[35] Monitoring and comparison might aid in the global effort to study and control AMD resistance.

Companion animals. Little is known about AMD resistance and transmission in companion animals. Individual cases likely go unnoticed and underreported. Companion animals as sources and potential vehicles of transmission of AMD resistance has been reported in recent years involving veterinary hospitals and animal shelters. [36] Because companion animals have extensive close contact with humans, and because pet-owners likely do not practice the same level of hygiene and risk mitigation as slaughter plants, the risk of transfer of AMD resistance from companion animal bacteria to human bacteria may be higher than from livestock bacteria.

Should some streams be eliminated?

The importance of looking at human and animal clinical isolates is straightforward. They signal emergence of new pathogenic isolates, and their ready

availability makes these isolates critical components of a national AMD resistance monitoring system.

Slaughter samples as well as retail meat samples, also readily available, are very close to the consumer in the food chain. Because they are easily and readily attainable, and because they represent a point of focused mitigation, their inclusion in NARMS data is important.

Although the addition of healthy animal data is likely a costly component and one that might be considered expendable, it is also one of the most important. Healthy on-farm samples allow us to compare healthy to sick, and to establish baselines. After all, it is presumably the healthy animals that are going to be made into food and thus potentially be the greatest source of exposure to the public.

Examination of all the streams of data allows us to learn not just "if" AMD resistance is occurring, but where, how and why it might be occurring. It also allows us the ability to know where in the process it might be occurring and thus facilitate intervention. The earlier we can intervene in the chain, the more precisely we can address and mitigate areas of concern.

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Table 8.1: Advantages, disadvantages and uniqueness of data streams used in AMD resistance monitoring in the US system.			
	Advantages	Disadvantages	Uniqueness
Animal clinical cases	How AR is emerging and evolving. New emergent forms of AR. Isolates readily available. Guides to empirical treatment. Allow for comparison of trends	Worst case/treatment failures. On its own, may over or over-represent AR. Lack of AMD usage data. Data lacking on species sub-groups.	Picture of what is occurring in animals?
Human clinical cases	How AR is emerging and evolving. New emergent forms of AR. Isolates readily available. Guides to empirical treatment. Allow for comparison of trends	Worst case/treatment failures. On its own, may over or over-represent AR. Lack of AMD usage data. Geographically limited. Sampling and reporting scheme bias.	Picture of what is occurring in humans?
Slaughter	Isolates readily available in large numbers as part of regulatory program. Relatively close to consumer.	Where does contamination really occur? Sampling scheme may over or under-represent AR. Lack of AMD usage data.	Large amount of data is good??
Retail meat	Very close to consumer. Easy to obtain.	Where does contamination really occur? Small numbers. Geographically limited. On its own, may over or under-represent AR.	Closest point to consumer.
Healthy on-farm	Control/comparison group	Low numbers. Intermittent data. Specific AMD use not recorded.	Important/mandatory as a control group. Allows us to compare other animal streams to what might be "normal". They are what we eat.

Summary

The goals of this research were to examine the essential components of veterinary public health practice – needs assessment, problem investigation and outreach and apply them to a variety of topics of current interest in the field.

Epidemiological needs assessment, problem investigation and their subsequent outreach programs are essential tools of veterinary public health practice. These tools were used to explore infection control, infectious and zoonotic disease awareness, environmental contamination with infectious/zoonotic agents and monitoring the consequences of treatment of infectious and zoonotic diseases with antimicrobial drugs (i.e. antimicrobial drug resistance). The specific venues for these explorations included animal shelters, a veterinary teaching hospital, a former soviet country and a United States governmental program.

A holistic approach was used with animal shelters to assess infection control and zoonotic disease awareness needs, investigate environmental contamination with a zoonotic disease, develop training tools and train animal shelter workers and volunteers. The needs assessment presented in Chapter 2 provided valuable information on characteristics of animal shelters, provided impetus for the problem investigation and the basis for outreach training. The problem investigation tool presented in Chapter 3 provided the first available information on the prevalence and extent of salmonella contamination in Colorado animal shelters. The outreach component presented in Chapter 4 provided a tool and reference for training; the training itself presented in Chapter 5 indicated gaps in knowledge in various aspects

of infection control and zoonotic disease awareness that could be addressed with training; provided a valuable service to regional animal shelters and reported on the positive results of training shelter workers.

The information gained from these 4 interrelated projects adds to the growing body of literature on U.S. animal shelters and their characteristics. More research needs to be done. Involving animal shelters up front and including their desires in future projects is beneficial in developing good relationships and empowering shelters by acknowledging their unique knowledge and understanding their priorities. Individually these projects serve a purpose by expanding our scientific knowledge of animal shelter needs and characteristics, potential disease issues and methods of training shelter workers. The greatest beneficiaries of a holistic approach are the shelters themselves. A holistic approach empowers individuals and has the best chance of leading to effective and sustainable change. The approach taken by this group of related studies in a focused area allowed for the information gathered in each study to inform the next and to meet the needs of shelters that they themselves identified.

Further, problem investigation is explored through the success of active surveillance in discovery and control of a zoonotic disease outbreak in a veterinary teaching hospital in Chapter 7. Although this paper was initially intended to be illustrative of problem investigation – closer examination reveals that this veterinary public health issue, like most all of them, includes all 3 essential components. Needs assessment was provided through an active surveillance system that alerted investigators to the developing problem, and successful resolution of

the situation depended upon effective, thorough, transparent outreach. This chapter illustrates the process underlying veterinary public health issues.

Results of a needs assessment survey in the Republic of Armenia presented in Chapter 6 provide the basis for development of outreach materials for veterinarians, farmers and school-age children on their national animal health program. The results of these surveys provided not only direction in the development of educational materials but also provided valuable information for those involved in animal health related work in Armenia on the perceptions of those surveyed, e.g. relative unimportance of biosecurity, lack of belief in the efficacy of extension programs. This research can help inform not only training but the development of programs in Armenia in the future.

In the outreach review paper presented in Chapter 8 the antimicrobial resistance monitoring system in the US is examined and challenged for completeness. It may at first appear to be a somewhat incongruous inclusion in this dissertation. But, it is illustrative of outreach first of all, needs assessment secondly and like the other non-animal shelter papers, illustrative of the meshing and overlapping of the essential components of veterinary public health matters. Needs assessment, problem investigation, and outreach occur in combination most of the time because they underlie the process of research. When we acknowledge the entire process and bring it to the forefront it can assist us in being more thorough and more accountable in our research endeavors. In science we are often focused on the tools and technology and outcome of problem investigation. We often forget to ask those involved and affected by these problems what they need and then

consider how we will disseminate the information back to them so they can learn and help inform what comes next. If we put research questions into a holistic framework, then, when a scientific discovery is made we are reminded to ask ourselves "what are the needs of those directly involved and what and how will they learn from these discoveries?"

Taken together, these studies further the examination of veterinary public health issues and highlight a holistic approach to their exploration.

Research needs/future directions

The results of these studies in animal shelters point to a need for more and better training of shelter workers and volunteers to protect animal as well as human health. Many workers and even more volunteers lack training. The institutionalization of shelter worker training in infection control and zoonotic disease awareness is necessary. In-person training would be the most effective method but development of on-line training could be very useful and reach a large number of individuals. Grants through organizations such as Maddies Fund or Morris Animal foundation could fund development of training offered through the HSUS, AHA or veterinary schools with shelter medicine groups.

The infection control practices that shelters do and do not employ are important in disease transmission. Some shelters have written infection control policies, but most do not. Assistance with written protocol development would be beneficial to animal shelters in the study region. An HSUS outreach office that worked directly with individual animal shelters to develop individualized infection control policies and procedures would be very useful.

The assistance shelters presently get and the input they receive from experts, including veterinarians, varies considerably. Some shelters have full time veterinarians on staff, many more have part time or consulting veterinarians and many only see or talk to a veterinarian when they bring a sick or injured animal to them and then they speak nothing of shelter management and disease control. Many programs are available to educate the shelter veterinarian, but we need to find ways to educate and inform shelters that do not have veterinarians on staff.

The shelter needs assessment and outreach projects in this dissertation measured perception of disease, not actual disease levels. Nor did they quantify the density of animals with perceived disease levels. Other institutions are currently conducting large scale disease prevalence studies on feline upper respiratory disease, the major cause of morbidity and mortality in animal shelters. More studies on other diseases would be welcome. The results of these studies will add to the growing body of shelter literature and help guide future shelter related projects.

Whether we call it "infection control" or "biosecurity" there exists a need in many sectors to raise the level of awareness of these important concepts. This is true in animal shelters as well as countries such as Armenia. Armenia needs extension programs that teach zoonotic disease awareness, and biosecurity. The utility and benefits of biosecurity, in a very explicit way, need to be illustrated and best practices taught and re-enforced.

Problem investigation in this dissertation focused for the most part on environmental contamination with salmonella. Veterinary teaching hospitals with client owned animals have more funds at their disposal and a compelling reason, in

their responsibility to clients, to perform diagnostic testing on animals themselves and look at samples for antimicrobial resistance and so forth. Animal shelters have fewer resources and are much less able to investigate disease problems. A clear need exists to investigate the findings from Chapter 3 more fully. Studies that include environmental sampling as well as animal sampling will help pinpoint the source of disease. Pilot studies in other regions, especially those with animal shelters in proximity to cattle populations will help clarify any relationship between environmental contamination with salmonella in companion animal shelters with cattle populations. Elaboration on the role of stress in shelter animals and shedding of salmonella would be informative. A closer look at zoonotic disease and studies measuring zoonotic diseases in shelter animals and the shelter workers would help take this discussion from one based on hypothetical risk and anecdotal evidence to real evidence of risk. Because of higher disease levels in animal shelters we often see high antimicrobial use. Drug use and susceptibility studies for common shelter diseases and commonly used shelter drugs could be very useful to shelters on limited budgets to treat animals. Reptiles were not significantly associated with environmental contamination in shelters, but evidence is highly suggestive that reptiles need to be dealt with in shelters in a manner that involves isolation and heightened personal protection of workers. More studies on reptiles in shelters would help explore this potential risk.

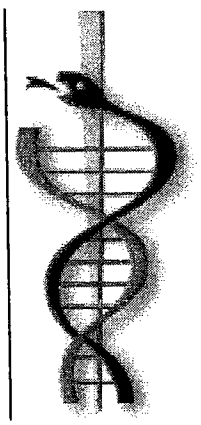
Both disease investigation studies used the electrostatic wipe method for environmental contamination evaluation. This method has not been validated or

scientifically compared to other methods of environmental evaluation. Work in this area would be welcome.

The training offered as part of these studies was effective in disseminating knowledge in the short term. Much more could be done with training and evaluation. Studies evaluating long term knowledge acquisition would offer the best evidence of the effectiveness of shelter worker training. Observational evaluation of behavioral change with regard to infection control principles; evaluation of behavioral intent through scenario participation; diagnostic evaluation of shelter disease levels before and after training; and evaluation of different methods of training would offer more solid evidence of effectiveness of shelter worker training projects in the future.

Appendix

Needs assessment survey sent to animal shelters used to assess characteristics and determine training needs.



Colorado State University
College of Veterinary Medicine and Biomedical Sciences
Department of Clinical Sciences

Animal Shelter Needs Assessment

1) What is your role at the shelter?
   a) ____ Shelter Director
   b) ____ Shelter Manager
   c) ____ Veterinarian-staff full time
   d) ____ Veterinarian-staff-part time
   e) ____ Veterinarian-consulting
   f) ____ Kennel manager/operations manager
   g) ____ Other: specify _____
2) How long have you been in this role?_____years
3) How long have you been with this shelter?_____years
4) Does your shelter have a computerized data system?
   a) ___ Yes
   b) ___ No
5) Do you keep medical records on animals who receive treatment at your shelter?
   a) ___ Yes
   b) ___ No
6) Is your shelter? Check most appropriate category.
   a) ____ Public
   b) ____ Private
   c) ____ Government
   d) ____ Combination private with government contracts
   e) ____ Other, specify:_____
7) Is your shelter…? (Check most appropriate answer.)
   a) ___ No kill

b) ___ Limited-admission
c) ___ Open-admission
d) ___ Sanctuary
e) ___ Rescue
f) ___ Other_____

8) What is the source of your animals?

a) Owner relinquishment	_____%
b) Stray	_____%
c) Municipal/County/Township Contracts	_____%
d) Other shelters/rescue organizations-local	_____%
e) Other shelters/rescue organizations-out of state	_____%
f) Other: Specify:_____	_____%
f) Unknown	_____%
	=100%

9) What is your average:

a) Adoption rate	_____%
b) Euthanasia rate	_____%
c) Reclaim rate	_____%
d) Transfer rate	_____%
e) Death rate	_____%
f) _____Rates unknown	

10) What is your estimated annual budget?_____

11) Approximately how many animals (of all species) are admitted to your shelter per year (annual intake population)? _____

12) How many full time staff members are usually employed at your shelter?

_____

13) How many part time staff members are usually employed in your shelter?_____

14) How many volunteers do you usually have at your shelter?

_____

15) What species of animals do you accept at your shelter? (Check all that apply.)

a) ____ Dogs
b) ____ Cats
c) ____ Birds
d) ____ Reptiles
e) ____ Amphibians
f) ____ Small mammals
g) ____ Pigs
h) ____ Small ruminants
i) ____ Horses
j) ____ Wildlife
k) ____ Other. Specify:_____

16) How many animals have the following conditions when they arrive at your shelter? Circle one number for each health condition.

None	Very Few	Many	Most

a) Injury (e.g. fracture, abrasions)
b) Malnutrition (e.g. underweight)
c) Infectious disease (e.g. respiratory infection)
d) Geriatric (e.g. dogs > 8 yrs)
e) Pediatric issues (e.g. bottle feeders)
f) Chronic Disease (e.g. hyperthyroid)
g) Dental issues (e.g. need dental prophy)
h) Skin diseases (e.g. allergies)

1	2	3	4
1	2	3	4
1	2	3	4
1	2	3	4
1	2	3	4
1	2	3	4
1	2	3	4
1	2	3	4

17) Please rate your level of concern about the following diseases/conditions in **animals** at your shelter?

a) Feline upper respiratory infection
b) Panleukopenia (feline distemper)
c) Ringworm
d) Plague
e) Kennel cough (Bordetella)
f) Canine Influenza Virus
g) Canine Distemper
h) Parvovirus
i) Leptospirosis
j) Internal parasites (e.g. roundworm)
k) External parasites (e.g. fleas,ticks)
l) Other:
Specify_____

No Concern	Slight Concern	Moderate Concern	Great Concern
1	2	3	4
1	2	3	4
1	2	3	4
1	2	3	4
1	2	3	4
1	2	3	4
1	2	3	4
1	2	3	4
1	2	3	4
1	2	3	4
1	2	3	4
1	2	3	4
1	2	3	4

18) What **zoonotic diseases** are of concern to you, working in your shelter? Circle one number for each zoonotic disease.

No Concern	Slight Concern	Moderate Concern	Great Concern
1	2	3	4
1	2	3	4
1	2	3	4
1	2	3	4
1	2	3	4
1	2	3	4
1	2	3	4
1	2	3	4
1	2	3	4

1	2	3	4
1	2	3	4

a) Plague
b) Tularemia
c) Psittacosis
d) Avian Influenza
e) Kennel cough (Bordetella)
f) Emerging Diseases (e.g. Monkey Pox)
g) Leptospirosis
h) Fecal parasites
i) Ringworm
j) Sarcoptic mange
k) Other: Specify_____

19) What do you think is the level of **infectious/contagious disease** in your shelter animals for the following diseases?

Canine Influenza Virus___|_____|_____|_____|____
Low Moderate High Unknown

Distemper Virus___|_____|_____|_____|_____
Low Moderate High Unknown

Feline Upper Respiratory Disease
___|_____|_____|_____|____
Low Moderate High Unknown

Kennel Cough
___|_____|_____|_____|____
Low Moderate High Unknown

Parvovirus
___|_____|_____|_____|____
Low Moderate High Unknown

Panleukopenia
___|_____|_____|_____|____
Low Moderate High Unknown

Internal parasites
___|_____|_____|_____|____
Low Moderate High Unknown

External parasites
___|_____|_____|_____|____
Low Moderate High Unknown

Kitten diarrhea
___|_____|_____|_____|_____
Low Moderate High Unknown

20) What do you think is the general overall level of **infectious/contagious disease** in your shelter animals?

___|_____|_____|_____|_____
Low Moderate High Unknown

21) What do you think is the level of **zoonotic disease** in your shelter animals for the following diseases? (Infectious/contagious diseases might include: kennel cough, feline upper respiratory disease, panleukopenia, parvovirus, canine influenza virus, distemper, internal and external parasites)

Avian influenza virus

___|_____|_____|_____|____

Low Moderate High Unknown

Campylobacter

___|_____|_____|_____|_____

Low Moderate High Unknown

Leptospirosis

__|_____|_____|_____|_____

Low Moderate High Unknown

Lyme disease

___|_____|_____|_____|_____

Low Moderate High Unknown

Plague __|_____|_____|_____|____

Low Moderate High Unknown

Psittacosis

___|_____|_____|_____|____

Low Moderate High Unknown

Salmonella

___|_____|_____|_____|_____

Low Moderate High Unknown

Sarcoptic Mange

___|_____|_____|_____|____

Low Moderate High Unknown

Ringworm

___|_____|_____|_____|____

Low Moderate High Unknown

Tularemia

___|_____|_____|_____|____

Low Moderate High Unknown

Internal parasites

___|_____|_____|_____|____

Low Moderate High Unknown

22) What do you think is the overall level of **zoonotic disease** in your shelter animals?

___|_____|_____|_____|_____

Low Moderate High Unknown

23) How comfortable are you with your shelters ability to identify animals with an **infectious disease**? (See question 19 for examples of infectious/contagious diseases)

___|_____|_____|_____

Not Comfortable Somewhat Comfortable Very Comfortable

24) How comfortable are you with your shelters ability to identify animals with a **zoonotic disease**? (See questions 21 for examples of zoonotic diseases.)

	Not Comfortable	Somewhat Comfortable	Very Comfortable

25) Regarding staff and volunteers at your shelter please check the appropriate box. (See questions 19 and 21 for examples of infectious/contagious and zoonotic diseases.)

a) How many are trained in the recognition of the clinical signs of infectious/contagious disease?
b) How many know what actions to take when an animal with an **infectious/contagious** disease is discovered?
c) How many know how the various **Infectious/contagious diseases** are spread.

Staff /volunteers

	None	Some	Few	Most
a				
b				
c				

a) How many are trained in the recognition of the clinical signs of **zoonotic** disease?
b) How many know what actions to take when an animal with an **zoonotic** disease is discovered?
c) How many know how the various **zoonotic** diseases are spread?

	None	Some	Few	Most
a				
b				
c				

26) Other than physical exam and the visual identification of clinical signs, what diagnostic tools are available to your shelter to diagnose disease if necessary? Check all that apply.

a) ____ Microscope
b) ____ Centrifuge
c) ____ Fecal testing (e.g. fecal float, fecal smear)
d) ____ Blood testing (e.g. felv, fiv)
e) ____ Blood panel (blood chemistry and CBC) – in house
f) ____ Blood panel (blood chemistry and CBC) – send out
g) ____Urine dipstick
h) ____Urine cytology
i) ____ Stains (e.g. wright stain, diff-quick)
j) ____ Radiographs
k) ____Woods Lamp
l) ____ Others: Please specify:_____

27) How often are diagnostic tools utilized?

Rarely | Occasionally | Often | Almost always

28) Does your shelter have an isolation area?
   a) ___Yes
   b) ___No

29) How many animals with **suspected** contagious diseases are put into isolation?

None | Some | Most | All | NA

30) How many animals with **confirmed** contagious diseases are put into isolation?

None | Some | Most | All | NA

31) Are **staff** trained on when and where to use appropriate barrier protection (e.g. gloves, gown, boots, and mask)?

No training | Some training | Extensive training

32) Are **volunteers** trained on when and where to use appropriate barrier protection (e.g. gloves, gown, boots, and mask)?

No training | Some training | Extensive training

33) Are equipment and supplies in the isolation area dedicated solely to isolation?

No/never | Sometimes | Often | Always

34) How often are footbaths used in your shelter?

Never | Sometimes | Often | Always

35) How often do you run out of cage space in the cat isolation area?

Never | Sometimes | Often | No cat iso

36) How often do you run out of cage space in the dog isolation area?

Never | Sometimes | Often | No dog iso

37) Is the general public restricted from visiting patients in isolation?
   a) ___Yes
   b) ___No
   c) ___I don't know

38) Do isolation patients have an area for defecation and urination separate from other shelter animals urination/defecation area?

a) ___Yes
b) ___No
c) ___Don't know

39) How often do you observe staff and volunteers washing their hands after animal contact?

_____|_____|_____|_____|_____
Rarely Sometimes Often Always

40) What method of communication is used by your shelter to inform the public about your animal handling policies? (e.g. washing hands between handling animals, visiting policies, etc.) Check all that apply.

a) ____ Verbal - the public is advised on our animal handling policies when they enter the shelter.

c) ____ Verbal - attendants in kennel/cage areas inform the public about animal handling policies as they are visiting animals.

b) ____ Signs - signs are posted in animal areas informing the public about animal handling policies.

d) ____ No methods of communication are used.

e) ____ Other:_____

41) Does your shelter have a **written protocol** for general cleaning and disinfection of the facility?

a) ___Yes
b) ___No
c) ___I don't know

42) Are individuals who are asked to be involved in cleaning and disinfection trained on disinfectant use and safety?

a) ___Yes
b) ___No
c) ___I don't know

43) Uniform policy. Check all that apply.

a) ____Uniforms are required for staff
b) ____Uniforms are required for volunteers
c) ____We provide uniforms for staff
d)____ We provide uniforms for volunteers.
e) ____Staff and volunteers are asked to bring in a change of clothing to work in.
f)_____Staff and volunteers wear whatever they want.

44) Does your shelter have a policy of not allowing food and drink in areas where animals are present?

a) ___Yes
b) ___No
c) ___I don't know

45) Is a separate refrigerator provided for staff and volunteer meals, that is not used for biological specimens or vaccines?

a) ___Yes
b) ___No

c) ___I don't know.

46) Regarding staff and volunteers, does your shelter maintain employee health records on:

	Yes	No	Don't know
a			
b			
c			
d			

a) Emergency contact information
b) Rabies vaccination status
c) Tetanus vaccination status
d) Seasonal influenza vaccination Status

47) Does your shelter have a written protocol on preventive medicine for animals (e.g. vaccination, de-worming, testing policy)?
a) ___Yes
b) ___No
c) ___We have a policy, but it is not written.

48) What vaccines are usually administered to dogs? Check all that apply.
i) ____DHLPP
ii) ____DHPP or DA2PP
iii) ____Rabies
iv) ____Bordetella
v) ____Other:
Specify_____

49) What vaccines are usually administered to cats? Check all that apply.
i) ____FVRCP
ii) ____FELV
iii) ____FIV
iv) ____Rabies
v) Other: specify_____

50) Do you have a schedule for revaccination if animals are kept for extended periods of time?
a) ___ Yes
b) ___ No
c) ___ I don't know

51) Are animals de-wormed at your shelter?
a) ___ Yes
b) ___ No
c) ___ I don't know

52) Do you have a schedule for repeat de-worming if animals are kept for an extended period of time?
a) ___ Yes
b) ___ No
c) ___ I don't know

53) Does your shelter have **specific written disease policies** for diseases of great concern (e.g. A written policy of how your shelter will handle an outbreak of parvo; or a suspect case of rabies, etc.)
a) ___ Yes
b) ___ No

c) ___ Each case is decided on an individual basis

54) Does your shelter have an infection control manual?
   a) ___ Yes
   b) ___ No
   c) ___ Other:
      Specify_____
   d) ___ I don't know

55) Have you received training in infection control through your shelter?
   a) ___ Yes
   b) ___ No
   c) ___ I don't know

56) Are individuals with animal contact advised of potential zoonotic disease risk to themselves?
   a) ___ Yes
   b) ___ No
   c) ___ I don't know

57) Are individuals with animal contact informed of increased risk of zoonotic disease if they are in any way immune compromised?
   a) ___ Yes
   b) ___ No
   c) ___ I don't know

58) How often is training in infectious disease given to staff? Check all that apply.
   a) ___ Upon hiring
   b) ___ Yearly
   c) ___ Intermittently, when problems arise
   d) ___ Routinely at staff training sessions or outside conferences
   e) ___ No training in infectious disease is given to staff.

59) How often is training in infectious disease given to volunteers? Check all that apply.
   a) ___ Upon hiring
   b) ___ Yearly
   c) ___ Intermittently, when problems arise
   d) ___ No training in infectious disease is given to volunteers.

60) Is disease transmission to humans discussed in this training?
   a) ___ Yes
   b) ___ No
   c) ___ I don't know
   d) ___ NA

61) If an animal is adopted out with, or recovering from, an infectious disease how often are adopters informed of potential risk of disease transmission to their pets at home?

Never		Sometimes	Often	Always

62) If an animal is adopted out with, or recovering from, a zoonotic disease how often are adopters informed of potential risk of disease transmission to themselves or their family members?

_____|_____|_____|_____|_____

Never Sometimes Often Always

63) What methods work best to inform and educate staff and volunteers at your shelter? Check all that apply.

a) ____Written materials-handouts
b) ____In-person training
c) ____ On the job training
d) ____On-line materials
e) ____Video
f) ____Combination of methods works best
g) ____Other:_____

64) Do you think your shelter would benefit from training in any of the following? Check all that apply.

a) ____Infectious disease
b) ____Zoonotic disease awareness
c) ____Cleaning and disinfection
d) ____We probably don't need any additional training
e) ____ Other. Please specify:_____

65) Who is in charge of infection control at your shelter?

a) ____Shelter Director
b) ____Shelter Manager
c) ____Veterinarian
d) ____There is no designated person in charge of infection control at our shelter.
e) ____Other:_____

66) Estimate what you spend per month on disinfectants at your shelter?

a) ____0-$100
b) ____$100-$200
c) ____$200-$300
d) ____>$300.

Brucellosis fact sheet developed for farmers based on report of surveys of Armenian veterinarians, farmers, teachers and the general public on preferences for outreach education information.

Brucellosis

Importance

Brucellosis is a bacterial disease. In cattle, illness is caused by the bacteria *Brucella abortus* and in sheep and goats it is caused by *B. melitensis.* Both are an economically important cause of abortions in animals. In humans brucellosis can cause a serious, debilitating and sometimes chronic disease. Human cases are from exposure to infected animals, or through ingestion of contaminated and unpasteurized dairy products (including milk and cheese).

Species Affected

There are many forms of the brucellosis bacteria. Each form is associated with a natural host. However, infection with *Brucella abortus* and *Brucella melitensis* can occur in other species, particularly when they are kept in close contact. While the natural hosts (or animals that are responsible for maintaining the infection) for *Brucella abortus* include cattle, bison (*Bison* spp.) water buffalo (*Bubalus bubalus*) and elk, infection has been recorded in feral pig populations, horses, sheep, goats, chamois, pigs, raccoons, opossums, dogs, coyotes, foxes, wolves and other species. *Brucella melitensis* mainly infects sheep and goats. Most breeds of goats are easily infected, but sheep breeds vary greatly in their ability to get the disease. *B. melitensis* infections have also been reported occasionally in cattle, camels and dogs, and rarely in horses and pigs.

The forms of brucellosis are listed below.

Species	Natural Host	Human Pathogen
B. abortus	cattle	yes
B. melitensis	goats, sheep	yes
B. suis	swine	yes
B. canis	dogs, other canids	yes
B. ovis	sheep	no

Transmission

Infection in animals most commonly occurs when they eat, drink or lick the organism or when the organism comes into contact with the insides of their mouth, nose and eyes. Animals are commonly infected through direct contact with birthing tissues or fluids or aborted tissues since the bacteria tends to be concentrated in these tissues. Other sources of infectious materials include the milk, urine, semen, feces and fluid filled abscesses on infected animals.

Infected animals can shed the bacteria intermittently in milk for prolonged periods of time or even for their entire lives.

Brucella abortus transmission can also occur from an infected mother to her offspring or through sexual contact of an infected bull to a female, however this route is uncommon. Infection be artificial insemination is reported to occur when contaminated semen is deposited in the uterus but not in the midcervix (contact your veterinarian for details on the proper procedures for artificial insemination).

Brucellosis can also be passed from one animal to another through broken skin and can be spread on inanimate objects like contaminated food, water, equipment and clothing. The organism can remain viable in debris like manure, aborted fetal tissue, or hay where it is protected from drying out. Survival of the bacteria is longer when the temperature is low, particularly when it is below freezing and the organism is protected from direct sunlight.

Other species infected with *B. abortus or B. melitensis* are dead end hosts since they generally shed the organism in levels too low to transmit to other animals. Dogs and coyotes do not seem to be a significant source of infection for other animals, however they do shed bacteria in reproductive discharges, and can infect cattle if kept in close contact. They can also act as a source of infection by dragging infected fetal or aborted tissue from one place to another.

Incubation Period

The incubation period is time between when an animal becomes infected with the bacteria and when the disease can be detected, either through evidence of clinical disease or by blood testing. The incubation period for brucellosis is variable, from 2 weeks to one year or longer in heifers.

Clinical Signs

B. abortus and *B. melitensis* most commonly cause abortions during the 5th to the 7th month of pregnancy. Animals can also be born alive but weak. After the first abortion, additional pregnancies are generally normal; however, animals may continue to shed the organism and become chronic carriers. A drop in milk production and the inability to become pregnant are less common signs in females.

Illness is less commonly seen in males. Swelling of leg joints, are a common symptom in some tropical countries seen in both sexes. Arthritis can develop in some long-term infections. Death due to brucellosis is rare except in the fetus or newborns. Infection in nonpregnant females often goes unnoticed. In previously unexposed and unvaccinated cattle, *B. abortus* and *B. melitensis* spreads rapidly and abortion storms are common. In herds where the disease is already present, only occasional abortions may appear particularly in animals with their first pregnancy.

Diagnosis and Control

Farmers should contact their veterinarian if they suspect infection in their herd or other community animals. Veterinarian can help determine if brucellosis is present in community animals and can provide strategies to minimize the spread of the disease to other animals and to reduce the risk of introducing it into a non-infected herd.

Serology can be used for a presumptive diagnosis of brucellosis, or to screen herds or flocks. Serological tests for individual cattle, sheep and goats include the buffered *Brucella* antigen tests (rose bengal test and buffered plate agglutination test), complement fixation, indirect or competitive enzyme-linked immunosorbent assays (ELISAs) or the fluorescence polarization assay . Serological tests are not completely specific and cannot always distinguish cross-reactions to other bacteria, particularly *Yersinia enterocolitica* O:9. Other serological tests include rivanol precipitation, acidified antigen procedures and the serum agglutination test (tube or micro-titer test). Supplemental tests such as complement fixation or rivanol precipitation are often used to clarify the results from plate or card agglutination tests. ELISAs or the *Brucella* milk ring test (BRT) can be used to screen herds by detecting antibodies in milk. In vaccinated cattle, sheep and goats the native hapten -based gel precipitation tests (gel diffusion or radial immunodiffusion tests) are sometimes used to distinguish vaccination from infection.

A definitive diagnosis can be made if *B. abortus* or *B. melitensis* is cultured from an animal. In cattle, the vaccine strains (*B. abortus* strains S19 and RB51) can be distinguished from field strains by their growth characteristics and sensitivity to antibiotics and other additives.

Polymerase chain reaction (PCR) techniques and other genetic techniques (restriction fragment length polymorphism or Southern blotting) are available in some laboratories.

Samples to Collect

Brucella abortus and *Brucella melitensis are* highly infectious to humans; samples should be collected and handled with all appropriate precautions.

A variety of samples can be collected for culture and microscopic examination. Milk samples and vaginal swabs are particularly useful for diagnosis in live animals. Milk samples for culture should contain milk from all four quarters. In addition, *Brucella sp.* can often be isolated from the secretions of nonlactating udders. This organism can also be cultured from aborted fetuses (stomach contents, spleen and lung) or the placenta. The spleen, mammary and genital lymph nodes, udder and late pregnant or early post-parturient uterus are the most reliable samples to collect at necropsy. *B. abortus and melitensis* can also be cultured from semen, the testis or epididymis, and arthritis or hygroma fluids.

Serum samples and milk samples can be collected for serology. Check with your district or regional laboratory on what samples are preferred for diagnosis.

Control and Eradication

Efforts are directed at detection, control and prevention because no practical treatment is available. Control of brucellosis can be accomplished largely through herd management and vaccination programs although eradication of the disease depends on testing and eliminating reactors. The disease has been eradicated from many individual herds and flocks and areas by this method. Animals must be tested at regular intervals until 2 or 3 successive tests are negative. Veterinarians should take an extensive history of the herd and develop a management plan tailored to the

specific herd or community. Herds can most effectively be managed through communication, cooperation and management between the veterinarian and the community/herd owners.

Herd Management

Brucellosis is usually introduced into a herd in an infected animal, but it can also enter in semen from infected bulls and on fomites (feed, farming tools, clothing etc.). In endemic areas, vaccinated calves or nonpregnant heifers are the best herd additions in uninfected herds. Pregnant or fresh cows should not be used as replacement animals. Breeding animals should not be added to a known infected herd.

Herd additions should be isolated for approximately a month and retested for before they are allowed to commingle with other community animals. Veterinarians should encourage all farmers that graze their animals together to practice safe herd management practices. They should also encourage immediate reporting and isolation of animals that exhibit signs of illness to the veterinarian for testing.

Any area exposed to infected animals and their birthing discharges should be thoroughly cleaned and disinfected or should be avoided as pasture land for a period of several months particularly during the winter. Infections in other species are generally prevented by controlling infection in its maintenance hosts however all species that have commingled with infected village animals need to be considered as a possible source of infection. If possible pregnant animals should be kept separate from the rest of the community herd particularly when they are about to give birth and care must be exercised to immediately remove any aborted tissues from the community grazing land. If possible this land should be disinfected immediately or a new grazing area can be used for a few months in cold weather or for a shorter period of time in warm sunny weather.

Two *B. abortus* vaccines, Strain 19 and RB51, can be used to control this disease in endemic areas, or used as part of a control program. Routine vaccination is often done in calves to minimize the production of persistent antibodies that can interfere with serological tests. RB51 is less likely than Strain 19 to induce persistent antibodies, and it is safer for humans. Both vaccines are live and can cause abortions in pregnant cattle and adverse effects in humans. Vaccination of calves with *B abortus* Strain 19 or RB51 increases resistance to infection. Resistance may not be complete, and some vaccinated calves may become infected, depending on severity of exposure. A small percentage of vaccinated calves develop antibodies to Strain 19 that may persist for years, which may confuse diagnostic test results. Strain RB51 is a rough attenuated strain that does not cause production of antibodies, which are detected by most serologic tests.

The *B. melitensis* Rev1 vaccine is used to control this disease in infected areas. Rev 1 can cause abortions in pregnant animals. This vaccine also interferes with serological tests, particularly when it is injected subcutaneously, but conjunctival administration to lambs and kids between the ages of 3 and 6 months minimizes this problem.

Vaccination should be used as a tool in part of a comprehensive herd management program. Reduction in the number of reactors in a herd is directly

related to the percentage of vaccinated animals. When proceeding from a control to an eradication program, a test and slaughter program is needed in cooperation with additional herd management techniques.

Disinfection

Brucella species are readily killed by most commonly available disinfectants including hypochlorite solutions, 70% ethanol, isopropanol, iodophores, phenolic disinfectants, formaldehyde, glutaraldehyde and xylene; however, organic matter and low temperatures decrease the efficacy of disinfectants. Disinfectants reported to destroy *Brucella* on contaminated surfaces include 2.5% sodium hypochlorite, 2-3% caustic soda, 20% freshly slaked lime suspension, or 2% formaldehyde solution (all tested for one hour). Alkyl quaternary ammonium compounds are not recommended. Autoclaving (moist heat of 121°C for at least 15 minutes) can be used to destroy *Brucella* species on contaminated equipment. These organisms can also be inactivated by dry heat [320-338° F (160-170°C) for at least 1 hour]. Boiling for 10 minutes is usually effective for liquids. Xylene (1ml/liter) and calcium cyanamide (20 kg/m3) are reported to decontaminate liquid manure after 2 to 4 weeks. *Brucella* species can also be inactivated by gamma irradiation (e.g. in colostrum) and pasteurization. Their persistence in unpasteurized cheese is influenced by the type of fermentation and ripening time. The fermentation time necessary to ensure safety in ripened, fermented cheeses in unknown, but is estimated to be approximately three months. *Brucella* survives for very short periods in meat, unless it is frozen; in frozen meat, survival times of years have been reported.

Public Health

While *B. abortus* can cause serious human disease, *B. melitensis* is highly pathogenic for humans; and is considered to be the most severe human pathogen in the genus. Occupational exposure is seen in laboratory workers, farmers, veterinarians, herders and others who contact infected animals or tissues. People who do not work with animals or tissues usually become infected by ingesting unpasteurized dairy products (including milk and cheese).

The Strain 19 *B. abortus* vaccine and the Rev-1 *B. melitensis* vaccine are also pathogenic for humans and must be handled with caution to avoid accidental injection or contamination of mucous membranes including splashing the vaccination into the eyes or abraded skin. Adverse events are also reported with the RB51 vaccine, although it appears to be safer than Strain 19.

Infection through ingestion of contaminated meat is rare since the organism does not concentrate in muscle tissue or the blood (unless the animal was bacteremic at the time of slaughter). However safe food handling techniques are necessary to avoid cross contamination of products intended for human consumption with the *Brucella* organism in contaminated tissues.

When assisting with birthing events a veterinarian should wear the appropriate protective clothing including long sleeves, eye protection, easily cleaned and disinfected outwear and disposable gloves. Any type of fetal or birthing tissue

should be disposed of properly and the birthing area should be disinfected appropriately if a communicable disease is suspected. Hands should be washed thoroughly after gloves are removed and disposed. If disposable gloves cannot be worn non- disposable gloves should be disinfected completely while using care that cross contamination does not occur. Care should also be taken to avoid contamination from one farm to the next through use of infected clothing or equipment.

Asymptomatic infections can occur in humans. In symptomatic cases, the disease is extremely variable and the clinical signs may appear gradually or abruptly. Typically, brucellosis begins as an acute febrile illness with nonspecific flu-like signs such as fever, headache, malaise, back pain, myalgia and generalized aches. Drenching sweats can occur, particularly at night. Some patients recover spontaneously, while others develop persistent symptoms that typically wax and wane. Occasionally seen complications include arthritis, spondylitis, chronic fatigue, and epididymoorchitis. Neurologic signs (including personality changes, meningitis, uveitis and optic neuritis), anemia, internal abscesses, nephritis, endocarditis and dermatitis can also occur. Other organs and tissues can also be affected, resulting in a wide variety of syndromes. Treatment is with antibiotics; however, relapses can be seen months after the initial symptoms, even in successfully treated cases. The mortality rate is low; in untreated persons, estimates of the case fatality rate vary from less than 2% to 5%. Deaths are usually caused by endocarditis or meningitis.

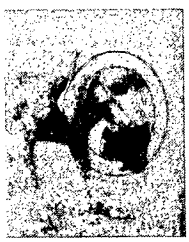
Brucellosis brochure for farmers based on report of surveys of Armenian veterinarians, farmers, teachers and the general public on preferences for outreach education information. (4-fold brochure, outside)

STEPS TO PREVENT DISEASE IN YOUR ANIMALS:

- REPORT all abortions, weak offspring or other signs of illness to your veterinarian.

- Test replacement animals before adding them to the herd.
  - If negative isolate them for 1 month and test again before adding them to the herd.
  - If positive, cull the infected animal.
- Separate infected pregnant animals from the rest of the herd when they are about to give birth.

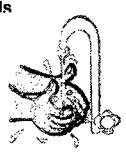
- Allow birth to take place outside of the barn so the sunlight can kill the bacteria.
- Do not throw birthing tissues in the irrigation canal and do not feed it to the dogs.
- Burn or deeply bury any birthing materials.



Your Veterinarian can help diagnose brucellosis and create an animal health management plan

WHAT CAN YOU DO TO KILL BRUCELLOSIS?

- Clean and disinfect any area where birthing, abortions or milking has taken place. You can use:
  - 2.5% sodium hypochlorite
  - 2-3% caustic soda,
  - 20% freshly slaked lime suspension
  - 2% formaldehyde solution
- Wash your hands with soap and water <u>before and after</u> milking animals, after touching birthing materials or animals



- Boil all milk products before consuming including milk and yogurt. Let cheese ferment for at least three months or longer.
- *BOILING the milk kills the bacteria.*

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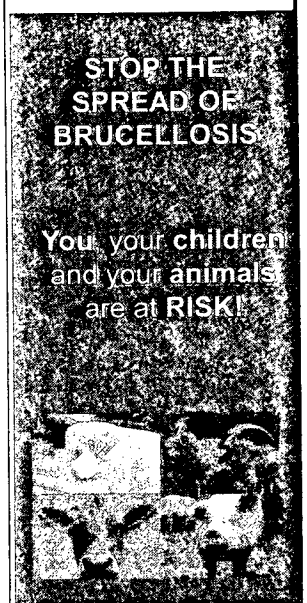


USDA Colorado State University

Brucellosis brochure for farmers based on report of surveys of Armenian veterinarians, farmers, teachers and the general public on preferences for outreach education information. (4-fold brochure, inside)

HUMAN RISKS

Symptoms in humans

- Night sweats
- High fluctuating fever
- Weakness
- Headache
- Localized abscesses

- Greater than 1 month for treatment and recovery time
- May not fully recover even if treated adequately!

HOW DO YOU GET INFECTED?

1.

By drinking and eating unpasteurized milk and cheese

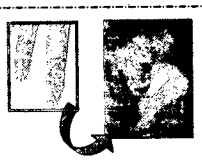
2.

By being exposed to birthing materials while handling new offspring of infected animals.

3.

When your eyes, mouth and open wounds have direct contact to milk and/or birthing tissues.

4.



By milking cows with cuts and scratches on your hand

ANIMAL RISKS

Symptoms in animals

CATTLE

- Abortion (usually 5-7th month of pregnancy)
- Lower conception rate
- Giving birth to weak calves
- Low milk production
- Cattle may show no signs but still spread the disease

SHEEP/GOATS

- Abortion
- Lower conception rate
- Giving birth to weak lamb and kids
- Low milk production
- Infertility in rams
- May show no signs but still spread the disease.

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HOW DOES THE DISEASE SPREAD?

From dam to offspring

- When offspring suckle from an infected dam, brucellosis bacteria are secreted in the milk and offspring become infected.
- Once an animal is infected, it is infected for life.

By ingestion

- If an animal licks a newborn animal, or eats grass that has been contaminated with birthing fluid

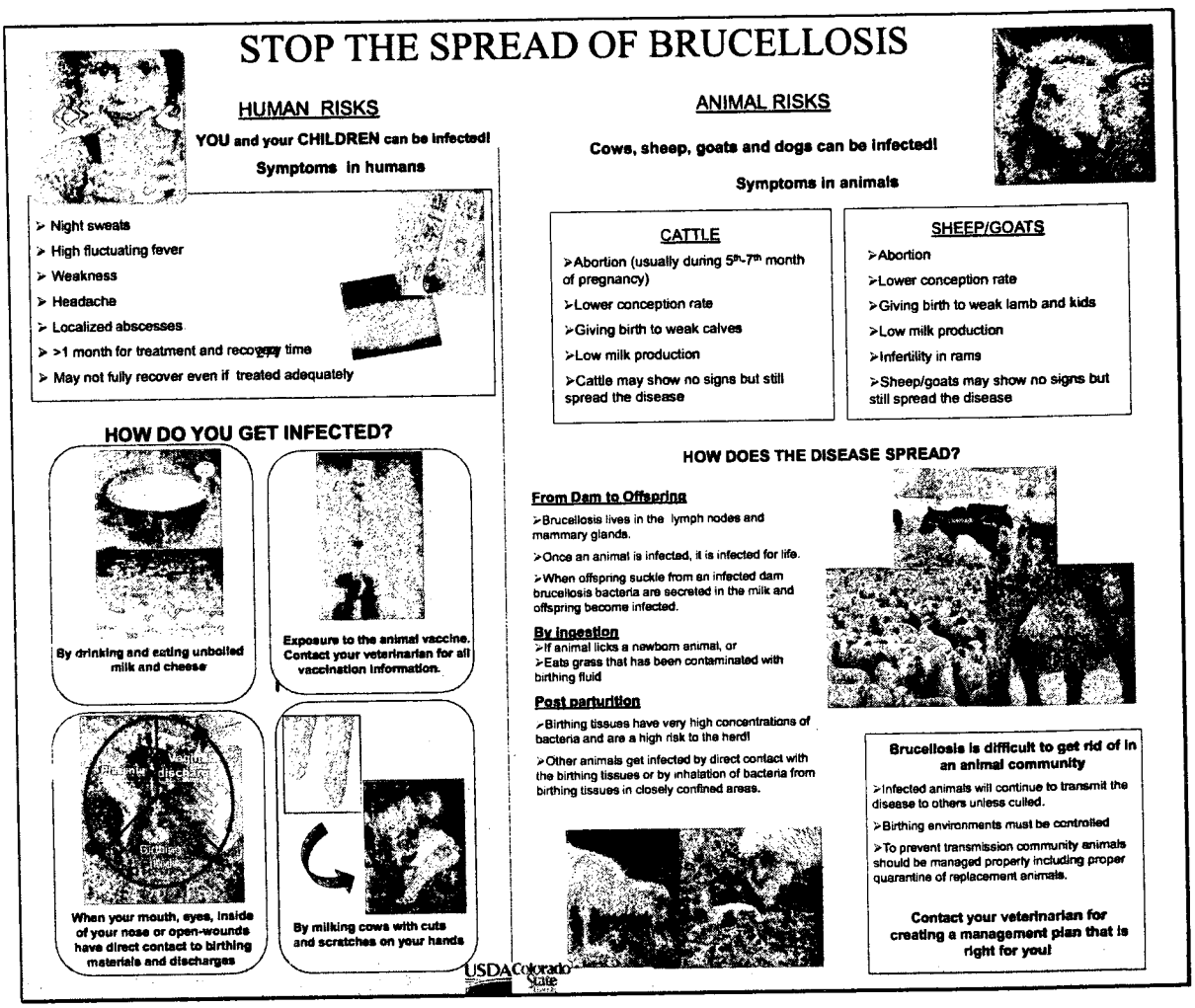
Post parturition

- Birthing tissues have very high concentrations of bacteria
- Other animals get infected by direct contact with the birthing tissues or by inhalation of bacteria from birthing tissues in closely confined areas.

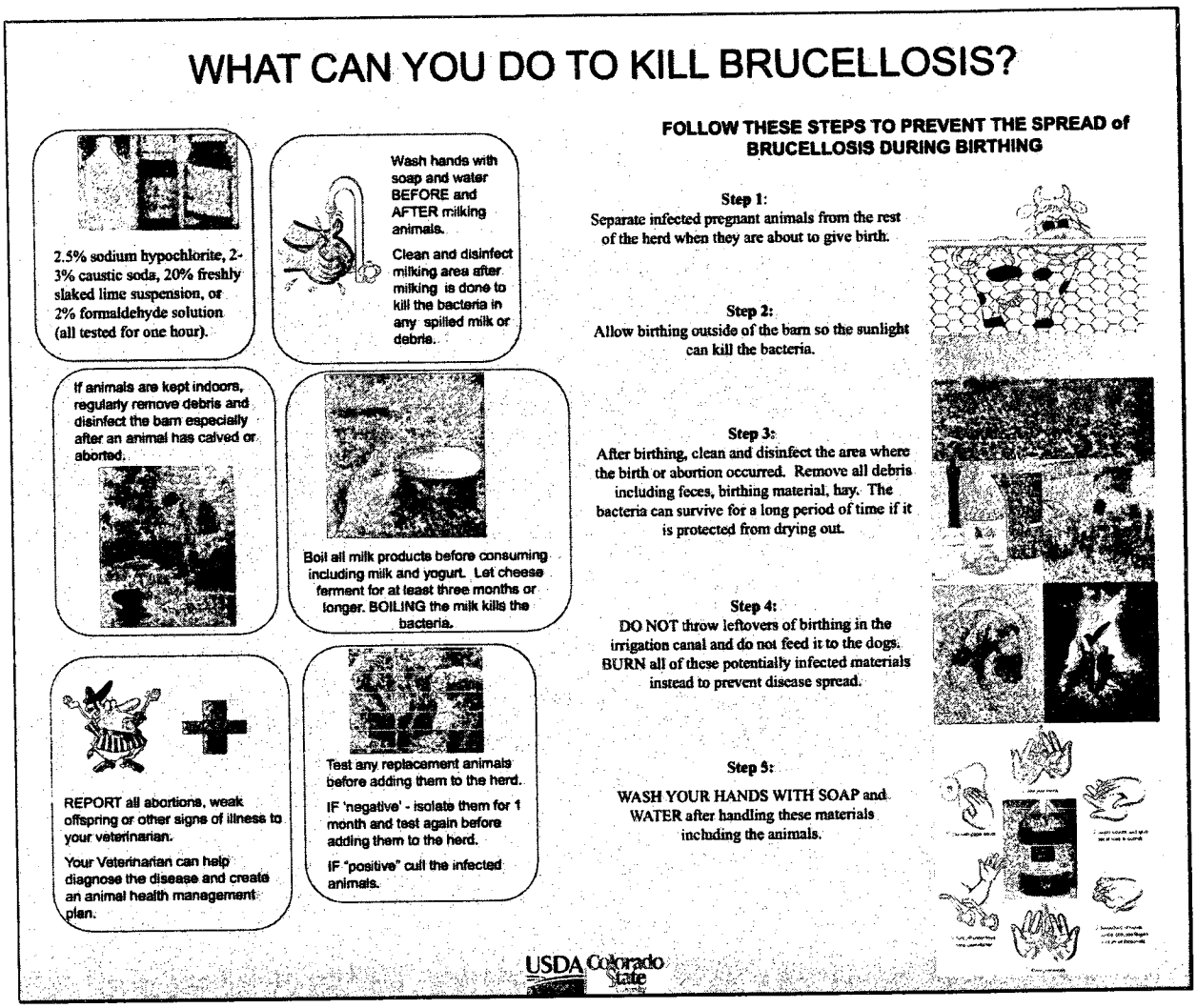
Brucellosis is difficult to get rid of in a community

- Infected animals will continue to transmit the disease to others unless culled.
- To prevent transmission community animals should be managed properly including proper quarantine of replacement animals.
- Contact your veterinarian to help create a management plan that is right for you!.

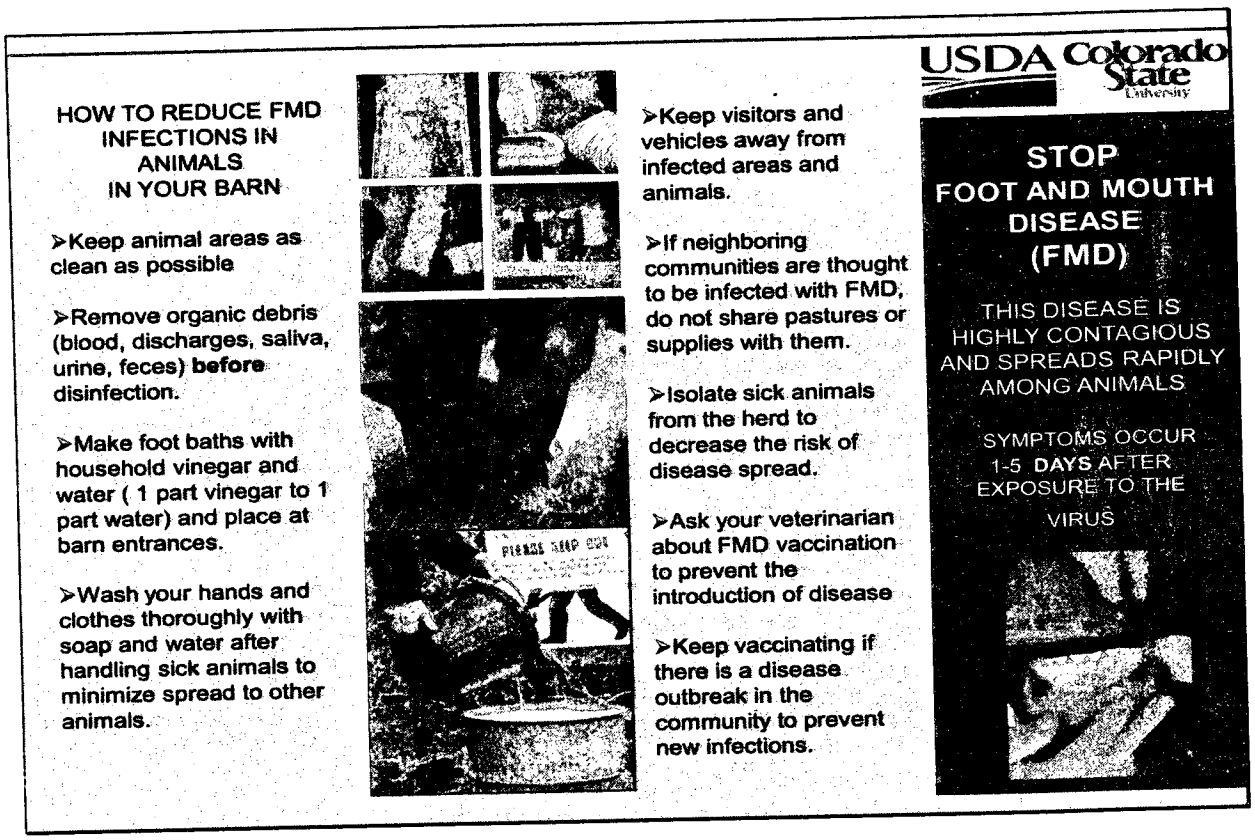
Brucellosis poster based on report of surveys of Armenian veterinarians, farmers, teachers and the general public on preferences for outreach education information. (Part 1)



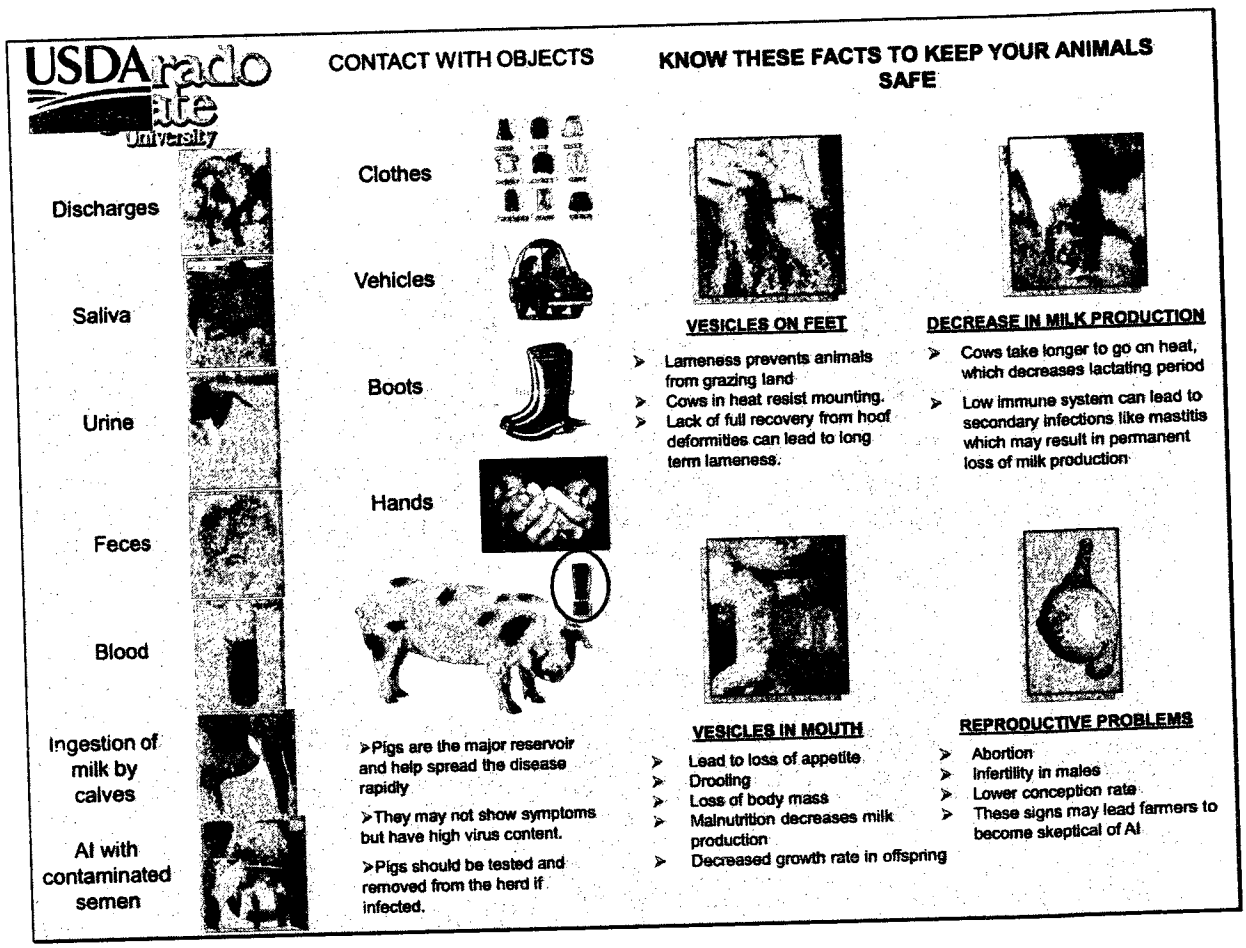
Brucellosis poster based on report of surveys of Armenian veterinarians, farmers, teachers and the general public on preferences for outreach education information. (Part 2)



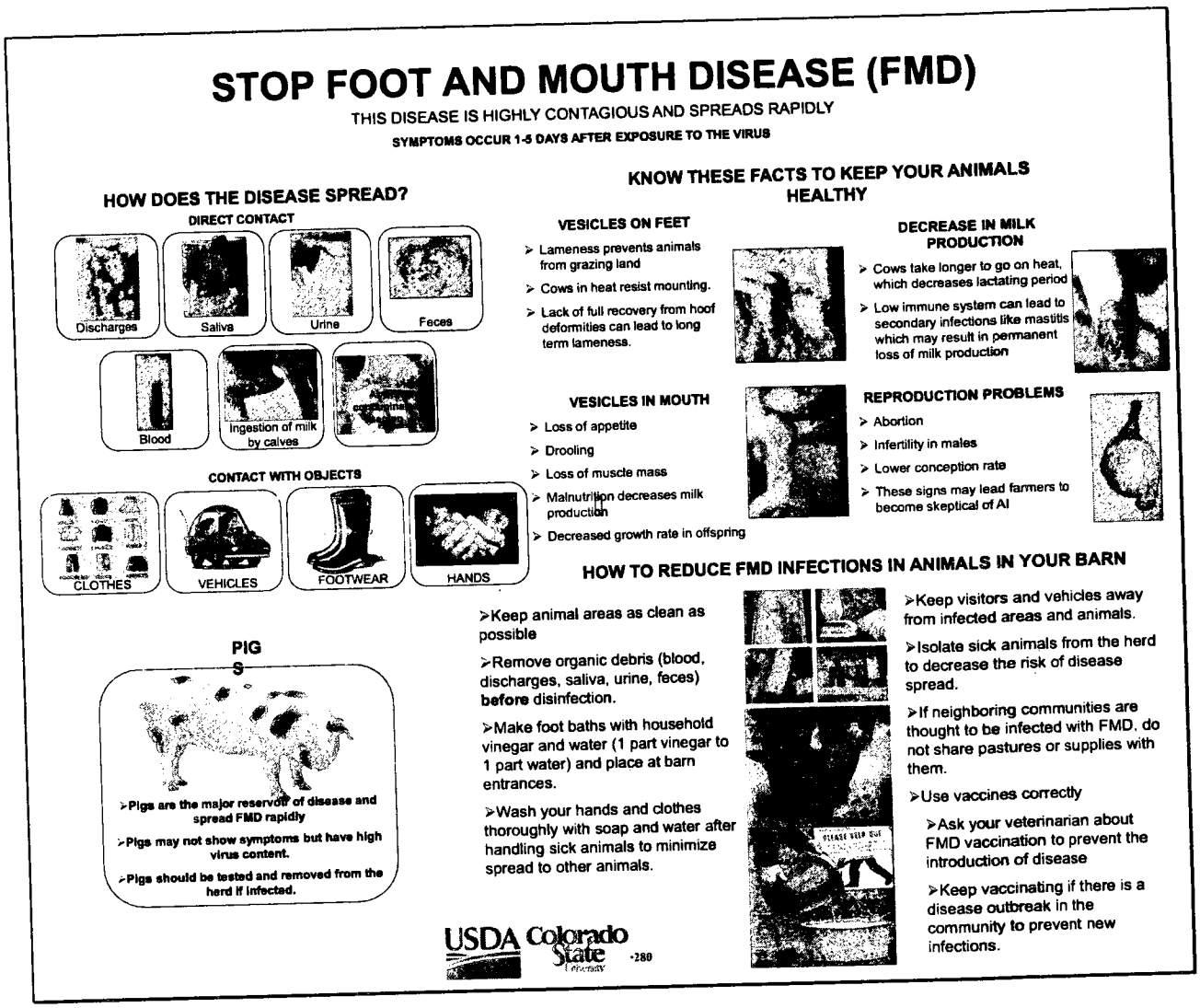
FMD brochure based on report of surveys of Armenian veterinarians, farmers, teachers and the general public on preferences for outreach education information. (4-fold brochure – outside)



FMD brochure based on report of surveys of Armenian veterinarians, farmers, teachers and the general public on preferences for outreach education information. (4-fold brochure – inside)



FMD poster based on report of surveys of Armenian veterinarians, farmers, teachers and the general public on preferences for outreach education information.



Test given to animal shelter workers and trainees used to assess infection control and zoonotic disease awareness knowledge.

What length of time have you worked in animal shelters? (Check the box that best describes your answer.)

- ☐ 0-6 months
- ☐ 6 months – 1 year
- ☐ 1 year – 2 years
- ☐ 2 years – 5 years
- ☐ 5 years – 10 years
- ☐ greater than 10 years

What is your role at this animal shelter? (Check the box that best describes your answer and fill in your job title.)

- ☐ Volunteer - describe duties or job title_____
- ☐ Paid staff – part time: Job title: _____
- ☐ Paid staff – full time: Job title: _____
- ☐ Other - describe duties or job title:_____

How many years have you been in this role at this shelter? (Check the box that best describes your answer.)

- ☐ 0-6 months
- ☐ 6 months – 1 year
- ☐ 1 year – 2 years
- ☐ 2 years – 5 years
- ☐ 5 years – 10 years
- ☐ greater than 10 years

The following is a list of diseases that might occur in an animal shelter. After each disease is a list of species, symptoms and routes of disease transmission. Please check all the boxes that you think apply to the particular disease.

Feline upper respiratory infection (URI)

Check the boxes in front of each animal species you believe can become infected with feline upper respiratory infection. Check all that apply.

☐dogs	☐cats	☐horses
☐birds	☐reptiles	☐small mammals (ferret, rabbit etc.)
☐livestock (cows, sheep, goat etc.)	☐ humans	☐wildlife

Check the box in front of each sign that can tell you if an animal is sick with feline upper respiratory infection? (Clinical signs of this disease). Check all boxes that apply

☐ abortion	☐ diarrhea	☐ oral ulcers	☐ swelling in throat region
☐ aggression	☐ fever	☐ paralysis	☐ sudden death
☐ animals might not show any sign of being sick	☐ hair loss	☐ pneumonia	☐ urinary tract infection
☐ blood in urine	☐ increased drinking/thirst	☐ scratching	☐ vomiting
☐ conjunctivitis	☐ increased urination	☐ seizure	☐ weight loss
☐ cough	☐ lameness	☐ skin sore/infection	☐ wound that doesn't heal
☐ chronic ear infections	☐ lethargy	☐ sneezing	
☐ decreased appetite	☐ nasal discharge		
☐ dehydration	☐ ocular discharge		

How could a shelter animal catch feline upper respiratory infection? (animal to animal transmission) Check all that apply.

☐ Direct contact transmission: An animal comes into contact with an infected animals' skin or coat; or is

bitten, licked or scratched by an infected animal.
☐ Aerosol or droplet transmission: Contaminated particles pass through the air (e.g. cough or sneeze or splattering urine) and are inhaled or come into contact with the lips, mouth, or eyes of a well animal.
☐ Oral transmission: An animal ingests fecal material; or food or water contaminated with fecal material, urine or other secretions.
☐ Fomite transmission: Fomites are objects such as food dishes, cages, brushes, laundry, hands of workers, or floor surfaces that are contaminated with feces, blood, saliva, or nasal secretions from sick animals. Disease is transmitted when the object is licked or the contaminated material comes into contact with their mouth, eyes, lips or skin.
☐ Vector transmission: From a flea, tick or mite bite .

How could a human catch feline upper respiratory infection? (animal to human transmission) Check all that apply.

☐ Not applicable: Humans can't get this disease from animals.
☐ Direct contact transmission: A human comes into contact with an infected animals' skin or coat; or is bitten, licked or scratched by an infected animal.
☐ Aerosol or droplet transmission: Contaminated particles pass through the air (e.g. cough or sneeze or splattering urine) and are inhaled or come into contact with the lips, mouth, or eyes of a human.
☐ Oral transmission: A human ingests fecal material; or food or water contaminated with fecal material, urine or other secretions.
☐ Fomite transmission: Fomites are objects such as food dishes, cages, brushes, laundry, hands of workers, or floor surfaces that are contaminated with feces, blood, saliva, or nasal secretions from sick animals. Disease is transmitted when humans make contact with the fomite and then inadvertently touch their mouth, eyes, lips or skin.
☐ Vector transmission: From a flea, tick or mite bite

Plague

Check the boxes in front of each animal species you believe can become infected with plague/ tularemia. Check all that apply.

☐dogs	☐cats	☐horses
☐birds	☐reptiles	☐small mammals (ferret, rabbit etc.)
☐livestock (cows, sheep, goat etc.)	☐ humans	☐wildlife

Check the box in front of each sign that can tell you if an animal is sick with plague. (Clinical signs of this disease). Check all boxes that apply

☐ abortion	☐ diarrhea	☐ oral ulcers	☐ swelling in throat region
☐ aggression	☐ fever	☐ paralysis	☐ sudden death
☐ animals might not show any sign of being sick	☐ hair loss	☐ pneumonia	☐ urinary tract infection
☐ blood in urine	☐ increased drinking/thirst	☐ scratching	☐ vomiting
☐ conjunctivitis	☐ increased urination	☐ seizure	☐ weight loss
☐ cough	☐ lameness	☐ skin sore/infection	☐ wound that doesn't heal
☐ chronic ear infections	☐ lethargy	☐ sneezing	
☐ decreased appetite	☐ nasal discharge		
☐ dehydration	☐ ocular discharge		

How could a shelter animal catch plague? (animal to animal transmission) Check all that apply.

☐ Direct contact transmission: An animal comes into contact with an infected animals' skin or coat; or is bitten, licked or scratched by an infected animal.
☐ Aerosol or droplet transmission: Contaminated particles pass through the air (e.g. cough or sneeze or splattering urine) and are inhaled or come into contact with the lips, mouth, or eyes of a well animal.
☐ Oral transmission: An animal ingests fecal material; or food or water contaminated with fecal material, urine or other secretions.
☐ Fomite transmission: Fomites are objects such as food dishes, cages, brushes, laundry, hands of workers,

or floor surfaces that are contaminated with feces, blood, saliva, or nasal secretions from sick animals. Disease is transmitted when the object is licked or the contaminated material comes into contact with their mouth, eyes, lips or skin.
☐ Vector transmission: From a flea, tick or mite bite

How could a human catch plague? (animal to human transmission) Check all that apply.

☐ Not applicable: Humans can't get this disease from animals.
☐ Direct contact transmission: A human comes into contact with an infected animals' skin or coat; or is bitten, licked or scratched by an infected animal.
☐ Aerosol or droplet transmission: Contaminated particles pass through the air (e.g. cough or sneeze or splattering urine) and are inhaled or come into contact with the lips, mouth, or eyes of a human.
☐ Oral transmission: A human ingests fecal material; or food or water contaminated with fecal material, urine or other secretions.
☐ Fomite transmission: Fomites are objects such as food dishes, cages, brushes, laundry, hands of workers, or floor surfaces that are contaminated with feces, blood, saliva, or nasal secretions from sick animals. Disease is transmitted when humans make contact with the fomite and then inadvertently touch their mouth, eyes, lips or skin.
☐ Vector transmission: From a flea, tick or mite bite

Ringworm

Check the boxes in front of each animal species you believe can become infected with ringworm. Check all that apply.

☐dogs	☐cats	☐horses
☐birds	☐reptiles	☐small mammals (ferret, rabbit etc.)
☐livestock (cows, sheep, goat etc.)	☐ humans	☐wildlife

Check the box in front of each sign that can tell you if an animal is sick with ringworm. (Clinical signs of this disease). Check all boxes that apply

☐ abortion	☐ diarrhea	☐ oral ulcers	☐ swelling in throat region
☐ aggression	☐ fever	☐ paralysis	☐ sudden death
☐ animals might not show any sign of being sick	☐ hair loss	☐ pneumonia	☐ urinary tract infection
☐ blood in urine	☐ increased drinking/thirst	☐ scratching	☐ vomiting
☐ conjunctivitis	☐ increased urination	☐ seizure	☐ weight loss
☐ cough	☐ lameness	☐ skin sore/infection	☐ wound that doesn't heal
☐ chronic ear infections	☐ lethargy	☐ sneezing	
☐ decreased appetite	☐ nasal discharge		
☐ dehydration	☐ ocular discharge		

How could a shelter animal catch ringworm? (animal to animal transmission) Check all that apply.

☐ Direct contact transmission: An animal comes into contact with an infected animals' skin or coat; or is bitten, licked or scratched by an infected animal.
☐ Aerosol or droplet transmission: Contaminated particles pass through the air (e.g. cough or sneeze or splattering urine) and are inhaled or come into contact with the lips, mouth, or eyes of a well animal.
☐ Oral transmission: An animal ingests fecal material; or food or water contaminated with fecal material, urine or other secretions.
☐ Fomite transmission: Fomites are objects such as food dishes, cages, brushes, laundry, hands of workers, or floor surfaces that are contaminated with feces, blood, saliva, or nasal secretions from sick animals. Disease is transmitted when the object is licked or the contaminated material comes into contact with their mouth, eyes, lips or skin.
☐ Vector transmission: From a flea, tick or mite bite .

How could a human catch ringworm? (animal to human transmission) Check all that apply.

☐ Not applicable: Humans can't get this disease from animals.

☐ Direct contact transmission: A human comes into contact with an infected animals' skin or coat; or is bitten, licked or scratched by an infected animal.
☐ Aerosol or droplet transmission: Contaminated particles pass through the air (e.g. cough or sneeze or splattering urine) and are inhaled or come into contact with the lips, mouth, or eyes of a human.
☐ Oral transmission: A human ingests fecal material; or food or water contaminated with fecal material, urine or other secretions.
☐ Fomite transmission: Fomites are objects such as food dishes, cages, brushes, laundry, hands of workers, or floor surfaces that are contaminated with feces, blood, saliva, or nasal secretions from sick animals. Disease is transmitted when humans make contact with the fomite and then inadvertently touch their mouth, eyes, lips or skin.
☐ Vector transmission: From a flea, tick or mite bite

Feline Panleukopenia

Check the boxes in front of each animal species you believe can become infected with feline panleukopenia. Check all that apply.

☐dogs	☐cats	☐horses
☐birds	☐reptiles	☐small mammals (ferret, rabbit etc.)
☐livestock (cows, sheep, goat etc.)	☐ humans	☐wildlife

Check the box in front of each sign that can tell you if an animal is sick with feline panleukopenia (Clinical signs of this disease). Check all boxes that apply.

☐ abortion	☐ diarrhea	☐ oral ulcers	☐ swelling in throat region
☐ aggression	☐ fever	☐ paralysis	☐ sudden death
☐ animals might not show any sign of being sick	☐ hair loss	☐ pneumonia	☐ urinary tract infection
☐ blood in urine	☐ increased drinking/thirst	☐ scratching	☐ vomiting
☐ conjunctivitis	☐ increased urination	☐ seizure	☐ weight loss
☐ cough	☐ lameness	☐ skin sore/infection	☐ wound that doesn't heal
☐ chronic ear infections	☐ lethargy	☐ sneezing	
☐ decreased appetite	☐ nasal discharge		
☐ dehydration	☐ ocular discharge		

How could a shelter animal catch feline panleukopenia? (animal to animal transmission) Check all that apply.

☐ Direct contact transmission: An animal comes into contact with an infected animals' skin or coat; or is bitten, licked or scratched by an infected animal.
☐ Aerosol or droplet transmission: Contaminated particles pass through the air (e.g. cough or sneeze or splattering urine) and are inhaled or come into contact with the lips, mouth, or eyes of a well animal.
☐ Oral transmission: An animal ingests fecal material; or food or water contaminated with fecal material, urine or other secretions.
☐ Fomite transmission: Fomites are objects such as food dishes, cages, brushes, laundry, hands of workers, or floor surfaces that are contaminated with feces, blood, saliva, or nasal secretions from sick animals. Disease is transmitted when the object is licked or the contaminated material comes into contact with their mouth, eyes, lips or skin.
☐ Vector transmission: From a flea, tick or mite bite

How could a human catch feline panleukopenia? (animal to human transmission) Check all that apply.

☐ Not applicable: Humans can't get this disease from animals.
☐ Direct contact transmission: A human comes into contact with an infected animals' skin or coat; or is bitten, licked or scratched by an infected animal.
☐ Aerosol or droplet transmission: Contaminated particles pass through the air (e.g. cough or sneeze or splattering urine) and are inhaled or come into contact with the lips, mouth, or eyes of a human.
☐ Oral transmission: A human ingests fecal material; or food or water contaminated with fecal material, urine or other secretions.

☐ Fomite transmission: Fomites are objects such as food dishes, cages, brushes, laundry, hands of workers, or floor surfaces that are contaminated with feces, blood, saliva, or nasal secretions from sick animals. Disease is transmitted when humans make contact with the fomite and then inadvertently touch their mouth, eyes, lips or skin.
☐ Vector transmission: From a flea, tick or mite bite

Rabies

Check the boxes in front of each animal species you believe can become infected with rabies. Check all that apply.

☐dogs	☐cats	☐horses
☐birds	☐reptiles	☐small mammals (ferret, rabbit etc.)
☐livestock (cows, sheep, goat etc.)	☐ humans	☐wildlife

Check the box in front of each sign that can tell you if an animal is sick with rabies. (Clinical signs of this disease). Check all boxes that apply.

☐ abortion	☐ diarrhea	☐ oral ulcers	☐ swelling in throat region
☐ aggression	☐ fever	☐ paralysis	☐ sudden death
☐ animals might not show any sign of being sick	☐ hair loss	☐ pneumonia	☐ urinary tract infection
☐ blood in urine	☐ increased drinking/thirst	☐ scratching	☐ vomiting
☐ conjunctivitis	☐ increased urination	☐ seizure	☐ weight loss
☐ cough	☐ lameness	☐ skin sore/infection	☐ wound that doesn't heal
☐ chronic ear infections	☐ lethargy	☐ sneezing	
☐ decreased appetite	☐ nasal discharge		
☐ dehydration	☐ ocular discharge		

How could a shelter animal catch rabies? (animal to animal transmission) Check all that apply.

☐ Direct contact transmission: An animal comes into contact with an infected animals' skin or coat; or is bitten, licked or scratched by an infected animal.
☐ Aerosol or droplet transmission: Contaminated particles pass through the air (e.g. cough or sneeze or splattering urine) and are inhaled or come into contact with the lips, mouth, or eyes of a well animal.
☐ Oral transmission: An animal ingests fecal material; or food or water contaminated with fecal material, urine or other secretions.
☐ Fomite transmission: Fomites are objects such as food dishes, cages, brushes, laundry, hands of workers, or floor surfaces that are contaminated with feces, blood, saliva, or nasal secretions from sick animals. Disease is transmitted when the object is licked or the contaminated material comes into contact with their mouth, eyes, lips or skin.
☐ Vector transmission: From a flea, tick or mite bite.

How could a human catch rabies? (animal to human transmission) Check all that apply.

☐ Not applicable: Humans can't get this disease from animals.
☐ Direct contact transmission: A human comes into contact with an infected animals' skin or coat; or is bitten, licked or scratched by an infected animal.
☐ Aerosol or droplet transmission: Contaminated particles pass through the air (e.g. cough or sneeze or splattering urine) and are inhaled or come into contact with the lips, mouth, or eyes of a human.
☐ Oral transmission: A human ingests fecal material; or food or water contaminated with fecal material, urine or other secretions.
☐ Fomite transmission: Fomites are objects such as food dishes, cages, brushes, laundry, hands of workers, or floor surfaces that are contaminated with feces, blood, saliva, or nasal secretions from sick animals. Disease is transmitted when humans make contact with the fomite and then inadvertently touch their mouth, eyes, lips or skin.
☐ Vector transmission: From a flea, tick or mite bite

Canine Parvovirus

Check the boxes in front of each animal species you believe can become infected with canine parvovirus. Check all that apply.

☐dogs	☐cats	☐horses
☐birds	☐reptiles	☐small mammals (ferret, rabbit etc.)
☐livestock (cows, sheep, goat etc.)	☐ humans	☐wildlife

Check the box in front of each sign that can tell you if an animal is sick with canine parvovirus (Clinical signs of this disease). Check all boxes that apply

☐ abortion	☐ diarrhea	☐ oral ulcers	☐ swelling in throat region
☐ aggression	☐ fever	☐ paralysis	☐ sudden death
☐ animals might not show any sign of being sick	☐ hair loss	☐ pneumonia	☐ urinary tract infection
☐ blood in urine	☐ increased drinking/thirst	☐ scratching	☐ vomiting
☐ conjunctivitis	☐ increased urination	☐ seizure	☐ weight loss
☐ cough	☐ lameness	☐ skin sore/infection	☐ wound that doesn't heal
☐ chronic ear infections	☐ lethargy	☐ sneezing	
☐ decreased appetite	☐ nasal discharge		
☐ dehydration	☐ ocular discharge		

How could a shelter animal catch canine parvovirus? (animal to animal transmission) Check all that apply.

☐ Direct contact transmission: An animal comes into contact with an infected animals' skin or coat; or is bitten, licked or scratched by an infected animal.
☐ Aerosol or droplet transmission: Contaminated particles pass through the air (e.g. cough or sneeze or splattering urine) and are inhaled or come into contact with the lips, mouth, or eyes of a well animal.
☐ Oral transmission: An animal ingests fecal material; or food or water contaminated with fecal material, urine or other secretions.
☐ Fomite transmission: Fomites are objects such as food dishes, cages, brushes, laundry, hands of workers, or floor surfaces that are contaminated with feces, blood, saliva, or nasal secretions from sick animals. Disease is transmitted when the object is licked or the contaminated material comes into contact with their mouth, eyes, lips or skin.
☐ Vector transmission: From a flea, tick or mite bite

How could a human catch canine parvovirus? (animal to human transmission) Check all that apply.

☐ Not applicable: Humans can't get this disease from animals.
☐ Direct contact transmission: A human comes into contact with an infected animals' skin or coat; or is bitten, licked or scratched by an infected animal.
☐ Aerosol or droplet transmission: Contaminated particles pass through the air (e.g. cough or sneeze or splattering urine) and are inhaled or come into contact with the lips, mouth, or eyes of a human.
☐ Oral transmission: A human ingests fecal material; or food or water contaminated with fecal material, urine or other secretions.
☐ Fomite transmission: Fomites are objects such as food dishes, cages, brushes, laundry, hands of workers, or floor surfaces that are contaminated with feces, blood, saliva, or nasal secretions from sick animals. Disease is transmitted when humans make contact with the fomite and then inadvertently touch their mouth, eyes, lips or skin.
☐ Vector transmission: From a flea, tick or mite bite

Canine Respiratory Disease

Check the boxes in front of each animal species you believe can become infected with canine respiratory disease. Check all that apply.

☐dogs	☐cats	☐horses
☐birds	☐reptiles	☐small mammals (ferret, rabbit etc.)
☐livestock (cows, sheep, goat etc.)	☐ humans	☐wildlife

Check the box in front of each sign that can tell you if an animal is sick with canine respiratory disease. (Clinical signs of this disease). Check all boxes that apply.

☐ abortion	☐ diarrhea	☐ oral ulcers	☐ swelling in throat region
☐ aggression	☐ fever	☐ paralysis	☐ sudden death
☐ animals might not show any sign of being sick	☐ hair loss	☐ pneumonia	☐ urinary tract infection
☐ blood in urine	☐ increased drinking/thirst	☐ scratching	☐ vomiting
☐ conjunctivitis	☐ increased urination	☐ seizure	☐ weight loss
☐ cough	☐ lameness	☐ skin sore/infection	☐ wound that doesn't heal
☐ chronic ear infections	☐ lethargy	☐ sneezing	
☐ decreased appetite	☐ nasal discharge		
☐ dehydration	☐ ocular discharge		

How could a shelter animal catch canine respiratory disease? (animal to animal transmission) Check all that apply.

☐ Direct contact transmission: An animal comes into contact with an infected animals' skin or coat; or is bitten, licked or scratched by an infected animal.
☐ Aerosol or droplet transmission: Contaminated particles pass through the air (e.g. cough or sneeze or splattering urine) and are inhaled or come into contact with the lips, mouth, or eyes of a well animal.
☐ Oral transmission: An animal ingests fecal material; or food or water contaminated with fecal material, urine or other secretions.
☐ Fomite transmission: Fomites are objects such as food dishes, cages, brushes, laundry, hands of workers, or floor surfaces that are contaminated with feces, blood, saliva, or nasal secretions from sick animals. Disease is transmitted when the object is licked or the contaminated material comes into contact with their mouth, eyes, lips or skin.
☐ Vector transmission: From a flea, tick or mite bite

How could a human catch canine respiratory disease? (animal to human transmission) Check all that apply.

☐ Not applicable: Humans can't get this disease from animals.
☐ Direct contact transmission: A human comes into contact with an infected animals' skin or coat; or is bitten, licked or scratched by an infected animal.
☐ Aerosol or droplet transmission: Contaminated particles pass through the air (e.g. cough or sneeze or splattering urine) and are inhaled or come into contact with the lips, mouth, or eyes of a human.
☐ Oral transmission: A human ingests fecal material; or food or water contaminated with fecal material, urine or other secretions.
☐ Fomite transmission: Fomites are objects such as food dishes, cages, brushes, laundry, hands of workers, or floor surfaces that are contaminated with feces, blood, saliva, or nasal secretions from sick animals. Disease is transmitted when humans make contact with the fomite and then inadvertently touch their mouth, eyes, lips or skin.
☐ Vector transmission: From a flea, tick or mite bite

Leptospirosis

Check the boxes in front of each animal species you believe can become infected with leptospirosis. Check all that apply. ☐dogs	☐cats	☐horses
☐birds	☐reptiles	☐small mammals (ferret, rabbit etc.)
☐livestock (cows, sheep, goat etc.)	☐ humans	☐wildlife

Check the box in front of each sign that can tell you if an animal is sick with leptospirosis. (Clinical signs of this disease). Check all boxes that apply

☐ abortion	☐ diarrhea	☐ oral ulcers	☐ swelling in throat region
☐ aggression	☐ fever	☐ paralysis	☐ sudden death
☐ animals might not show any sign of being	☐ hair loss	☐ pneumonia	☐ urinary tract infection

sick			
☐ blood in urine	☐ increased drinking/thirst	☐ scratching	☐ vomiting
☐ conjunctivitis	☐ increased urination	☐ seizure	☐ weight loss
☐ cough	☐ lameness	☐ skin sore/infection	☐ wound that doesn't heal
☐ chronic ear infections	☐ lethargy	☐ sneezing	
☐ decreased appetite	☐ nasal discharge		
☐ dehydration	☐ ocular discharge		

How could a shelter animal catch leptospirosis? (animal to animal transmission) Check all that apply.

☐ Direct contact transmission: An animal comes into contact with an infected animals' skin or coat; or is bitten, licked or scratched by an infected animal.
☐ Aerosol or droplet transmission: Contaminated particles pass through the air (e.g. cough or sneeze or splattering urine) and are inhaled or come into contact with the lips, mouth, or eyes of a well animal.
☐ Oral transmission: An animal ingests fecal material; or food or water contaminated with fecal material, urine or other secretions.
☐ Fomite transmission: Fomites are objects such as food dishes, cages, brushes, laundry, hands of workers, or floor surfaces that are contaminated with feces, blood, saliva, or nasal secretions from sick animals. Disease is transmitted when the object is licked or the contaminated material comes into contact with their mouth, eyes, lips or skin.
☐ Vector transmission: From a flea, tick or mite bite

How could a human catch leptospirosis? (animal to human transmission) Check all that apply.

☐ Not applicable: Humans can't get this disease from animals.
☐ Direct contact transmission: A human comes into contact with an infected animals' skin or coat; or is bitten, licked or scratched by an infected animal.
☐ Aerosol or droplet transmission: Contaminated particles pass through the air (e.g. cough or sneeze or splattering urine) and are inhaled or come into contact with the lips, mouth, or eyes of a human.
☐ Oral transmission: A human ingests fecal material; or food or water contaminated with fecal material, urine or other secretions.
☐ Fomite transmission: Fomites are objects such as food dishes, cages, brushes, laundry, hands of workers, or floor surfaces that are contaminated with feces, blood, saliva, or nasal secretions from sick animals. Disease is transmitted when humans make contact with the fomite and then inadvertently touch their mouth, eyes, lips or skin.
☐ Vector transmission: From a flea, tick or mite bite

Parasites-internal (roundworms and hookworms)

Check the boxes in front of each animal species you believe can become infected with internal parasites. Check all that apply.

☐dogs	☐cats	☐horses
☐birds	☐reptiles	☐small mammals (ferret, rabbit etc.)
☐livestock (cows, sheep, goat etc.)	☐ humans	☐wildlife

Check the box in front of each sign that can tell you if an animal is sick with internal parasites. (Clinical signs of this disease). Check all boxes that apply.

☐ abortion	☐ diarrhea	☐ oral ulcers	☐ swelling in throat region
☐ aggression	☐ fever	☐ paralysis	☐ sudden death
☐ animals might not show any sign of being sick	☐ hair loss	☐ pneumonia	☐ urinary tract infection
☐ blood in urine	☐ increased drinking/thirst	☐ scratching	☐ vomiting
☐ conjunctivitis	☐ increased urination	☐ seizure	☐ weight loss
☐ cough	☐ lameness	☐ skin sore/infection	☐ wound that doesn't heal

☐ chronic ear infections	☐ lethargy	☐ sneezing	
☐ decreased appetite	☐ nasal discharge		
☐ dehydration	☐ ocular discharge		

How could a shelter animal catch internal parasites? (animal to animal transmission) Check all that apply.

☐ Direct contact transmission: An animal comes into contact with an infected animals' skin or coat; or is bitten, licked or scratched by an infected animal.
☐ Aerosol or droplet transmission: Contaminated particles pass through the air (e.g. cough or sneeze or splattering urine) and are inhaled or come into contact with the lips, mouth, or eyes of a well animal.
☐ Oral transmission: An animal ingests fecal material; or food or water contaminated with fecal material, urine or other secretions.
☐ Fomite transmission: Fomites are objects such as food dishes, cages, brushes, laundry, hands of workers, or floor surfaces that are contaminated with feces, blood, saliva, or nasal secretions from sick animals. Disease is transmitted when the object is licked or the contaminated material comes into contact with their mouth, eyes, lips or skin.
☐ Vector transmission: From a flea, tick or mite bite

How could a human catch internal parasites? (animal to human transmission) Check all that apply.

☐ Not applicable: Humans can't get this disease from animals.
☐ Direct contact transmission: A human comes into contact with an infected animals' skin or coat; or is bitten, licked or scratched by an infected animal.
☐ Aerosol or droplet transmission: Contaminated particles pass through the air (e.g. cough or sneeze or splattering urine) and are inhaled or come into contact with the lips, mouth, or eyes of a human.
☐ Oral transmission: A human ingests fecal material; or food or water contaminated with fecal material, urine or other secretions.
☐ Fomite transmission: Fomites are objects such as food dishes, cages, brushes, laundry, hands of workers, or floor surfaces that are contaminated with feces, blood, saliva, or nasal secretions from sick animals. Disease is transmitted when humans make contact with the fomite and then inadvertently touch their mouth, eyes, lips or skin.
☐ Vector transmission: From a flea, tick or mite bite

Methicillin Resistant Staphylococcus Aureus (MRSA)

Check the boxes in front of each animal species you believe can become infected with this disease. Check all that apply.

☐dogs	☐cats	☐horses
☐birds	☐reptiles	☐small mammals (ferret, rabbit etc.)
☐livestock (cows, sheep, goat etc.)	☐ humans	☐wildlife

Check the box in front of each sign that can tell you if an animal is sick with methicillin resistant staphylococcus aureus. (Clinical signs of this disease). Check all boxes that apply

☐ abortion	☐ diarrhea	☐ oral ulcers	☐ swelling in throat region
☐ aggression	☐ fever	☐ paralysis	☐ sudden death
☐ animals might not show any sign of being sick	☐ hair loss	☐ pneumonia	☐ urinary tract infection
☐ blood in urine	☐ increased drinking/thirst	☐ scratching	☐ vomiting
☐ conjunctivitis	☐ increased urination	☐ seizure	☐ weight loss
☐ cough	☐ lameness	☐ skin sore/infection	☐ wound that doesn't heal
☐ chronic ear infections	☐ lethargy	☐ sneezing	
☐ decreased appetite	☐ nasal discharge		
☐ dehydration	☐ ocular discharge		

How could a shelter animal catch methicillin resistant staphylococcus aureus? (animal to animal transmission) Check all that apply.

☐ Direct contact transmission: An animal comes into contact with an infected animals' skin or coat; or is

bitten, licked or scratched by an infected animal.
☐ Aerosol or droplet transmission: Contaminated particles pass through the air (e.g. cough or sneeze or splattering urine) and are inhaled or come into contact with the lips, mouth, or eyes of a well animal.
☐ Oral transmission: An animal ingests fecal material; or food or water contaminated with fecal material, urine or other secretions.
☐ Fomite transmission: Fomites are objects such as food dishes, cages, brushes, laundry, hands of workers, or floor surfaces that are contaminated with feces, blood, saliva, or nasal secretions from sick animals. Disease is transmitted when the object is licked or the contaminated material comes into contact with their mouth, eyes, lips or skin.
☐ Vector transmission: From a flea, tick or mite bite.

How could a human catch methicillin resistant staphylococcus aureus? (animal to human transmission) Check all that apply.

☐ Not applicable: Humans can't get this disease from animals.
☐ Direct contact transmission: A human comes into contact with an infected animals' skin or coat; or is bitten, licked or scratched by an infected animal.
☐ Aerosol or droplet transmission: Contaminated particles pass through the air (e.g. cough or sneeze or splattering urine) and are inhaled or come into contact with the lips, mouth, or eyes of a human.
☐ Oral transmission: A human ingests fecal material; or food or water contaminated with fecal material, urine or other secretions.
☐ Fomite transmission: Fomites are objects such as food dishes, cages, brushes, laundry, hands of workers, or floor surfaces that are contaminated with feces, blood, saliva, or nasal secretions from sick animals. Disease is transmitted when humans make contact with the fomite and then inadvertently touch their mouth, eyes, lips or skin.
☐ Vector transmission: From a flea, tick or mite bite

Salmonella/Campylobacter

Check the boxes in front of each animal species you believe can become infected with salmonella / campylobacter. Check all that apply.

☐dogs	☐cats	☐horses
☐birds	☐reptiles	☐small mammals (ferret, rabbit etc.)
☐livestock (cows, sheep, goat etc.)	☐ humans	☐wildlife

Check the box in front of each sign that can tell you if an animal is sick with salmonella/campylobacter. (Clinical signs of this disease). Check all boxes that apply.

☐ abortion	☐ diarrhea	☐ oral ulcers	☐ swelling in throat region
☐ aggression	☐ fever	☐ paralysis	☐ sudden death
☐ animals might not show any sign of being sick	☐ hair loss	☐ pneumonia	☐ urinary tract infection
☐ blood in urine	☐ increased drinking/thirst	☐ scratching	☐ vomiting
☐ conjunctivitis	☐ increased urination	☐ seizure	☐ weight loss
☐ cough	☐ lameness	☐ skin sore/infection	☐ wound that doesn't heal
☐ chronic ear infections	☐ lethargy	☐ sneezing	
☐ decreased appetite	☐ nasal discharge		
☐ dehydration	☐ ocular discharge		

How could a shelter animal catch salmonella / campylobacter? (animal to animal transmission) Check all that apply.

☐ Direct contact transmission: An animal comes into contact with an infected animals' skin or coat; or is bitten, licked or scratched by an infected animal.
☐ Aerosol or droplet transmission: Contaminated particles pass through the air (e.g. cough or sneeze or splattering urine) and are inhaled or come into contact with the lips, mouth, or eyes of a well animal.
☐ Oral transmission: An animal ingests fecal material; or food or water contaminated with fecal material, urine or other secretions.

☐ Fomite transmission: Fomites are objects such as food dishes, cages, brushes, laundry, hands of workers, or floor surfaces that are contaminated with feces, blood, saliva, or nasal secretions from sick animals. Disease is transmitted when the object is licked or the contaminated material comes into contact with their mouth, eyes, lips or skin.
☐ Vector transmission: From a flea, tick or mite bite

How could a human catch salmonella /campylobacter? (animal to human transmission) Check all that apply.

☐ Not applicable: Humans can't get this disease from animals.
☐ Direct contact transmission: A human comes into contact with an infected animals' skin or coat; or is bitten, licked or scratched by an infected animal.
☐ Aerosol or droplet transmission: Contaminated particles pass through the air (e.g. cough or sneeze or splattering urine) and are inhaled or come into contact with the lips, mouth, or eyes of a human.
☐ Oral transmission: A human ingests fecal material; or food or water contaminated with fecal material, urine or other secretions.
☐ Fomite transmission: Fomites are objects such as food dishes, cages, brushes, laundry, hands of workers, or floor surfaces that are contaminated with feces, blood, saliva, or nasal secretions from sick animals. Disease is transmitted when humans make contact with the fomite and then inadvertently touch their mouth, eyes, lips or skin.
☐ Vector transmission: From a flea, tick or mite bite

Check 5 types of individuals you believe might be at highest risk of getting sick from a zoonotic disease (disease transmitted from animal to human). ***Choose 5 appropriate answers.***

☐ College students	☐ Vegetarians	☐ Children under the age of 5
☐ High school students	☐ People with HIV/AIDS	☐ Parents
☐ People with cancer	☐ College students	☐ People with diabetes
☐ People with an organ transplant	☐ People with acne	☐ People over age 65
☐ Urban dwellers	☐ Pregnant women	☐ Country dwellers
☐ Alcoholics	☐ Organ donors	☐ Elementary school students
☐ People with depression	☐ People with heart disease	☐ Junior high school students
☐ Malnourished people	☐ People with kidney failure	

Check the 5 activities that you believe can best help prevent disease spread in your animal shelter. (*Choose the 5 best answers.*)

☐ Wear gloves when handling sick animals	
☐ Use footbaths in every room	☐ Limit contact with sick animals
☐ Isolate sick animals from healthy animals	☐ Wash hands or use hand sanitizer
☐ Dispose of infectious/zoonotic waste appropriately	☐ Vaccinate/deworm animals after adoption
☐ Vaccinate all employees for influenza	☐ Separate male and female animals in wards
☐ Prohibit animal contact by potential adopters	

Check the 3 activities/ideas that you believe are most important in shelter sanitation. (*Choose the 3 best answers.*)

☐ Use the strongest disinfectant possible
☐ Mechanically remove all visible debris
☐ With the proper disinfectant, you can kill all organisms.
☐ Disinfect
☐ Mixing cleaning/disinfecting products is usually okay.
☐ Perfection in cleaning and disinfecting should be strived for
☐ Increasing the concentration of disinfectant will kill more bugs.
☐ Clean using a detergent or soap

What is a carrier animal? (*Circle the best answer.*)

A. An animal who is incubating a disease and about to become sick.
B. An animal who is chronically infected with a disease and sporadically shedding a disease organism.
C. An animal who recently recovered from a disease.
D. None of the above
E. A, B and C